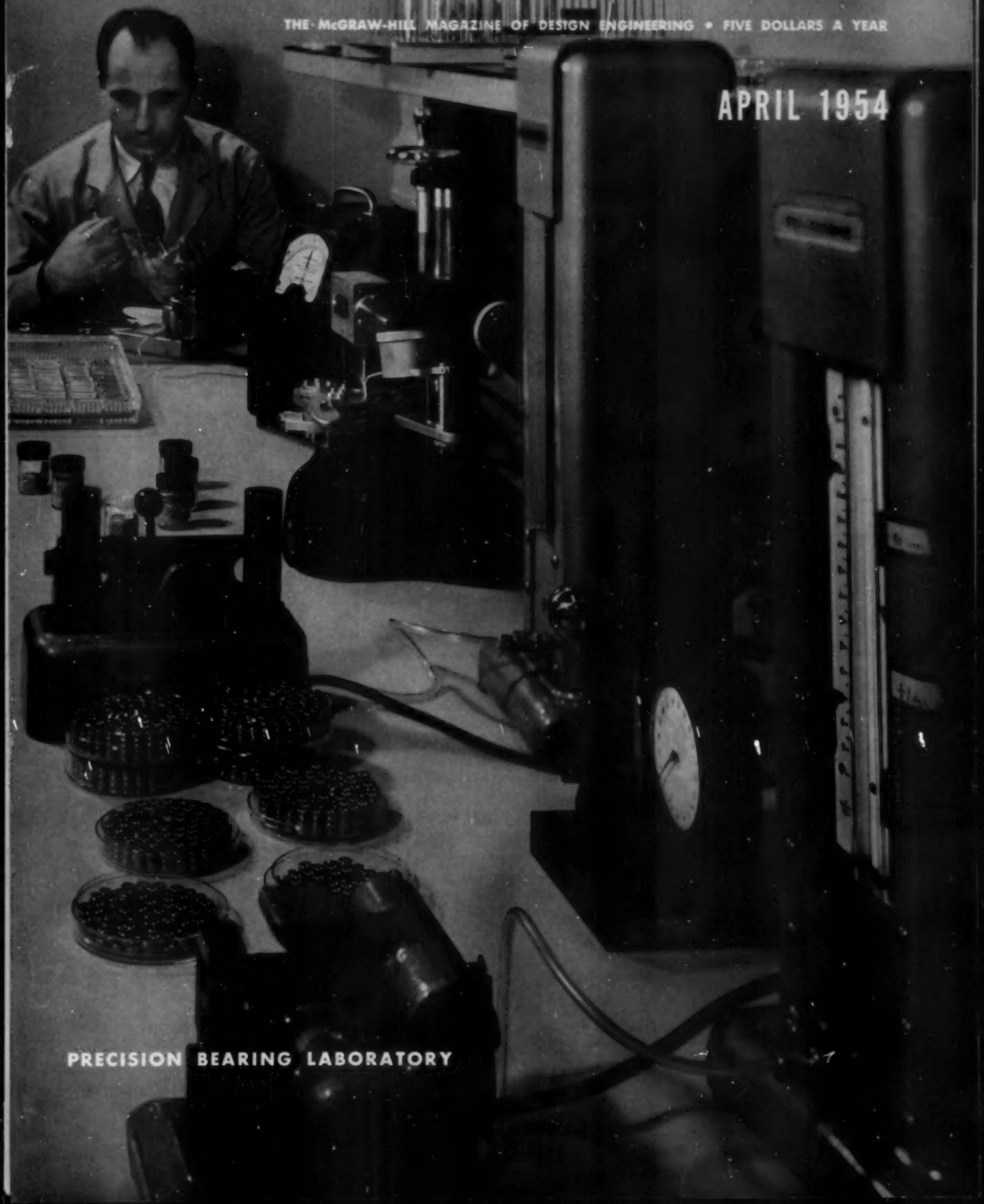
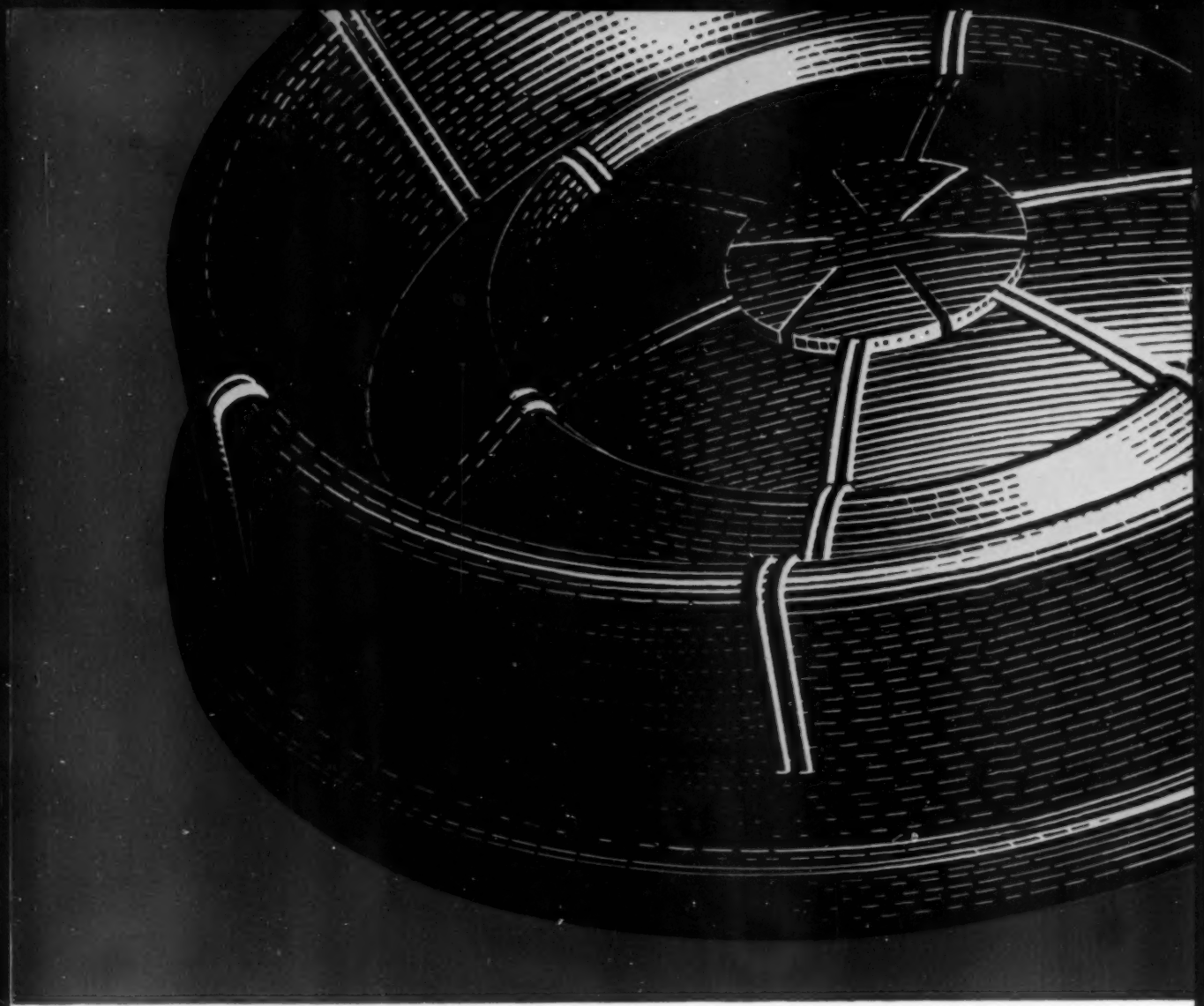
Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN ENGINEERING • FIVE DOLLARS A YEAR

APRIL 1954



PRECISION BEARING LABORATORY



BIG PART IN BIG PLANES This is a full-scale section of the Sirvene (synthetic rubber) diaphragm that works the wing flaps and other hydraulic devices in big planes. It must be equally perfect . . . in the first or the fifty thousandth hour of flight . . . at —65°F. or 180°F. above. And it is. Completely custom-developed, in design, compounding of oil-resistant elastomers, molding, and laboratory control of production, it well represents *all* Sirvene parts. It represents, too, the cooperation which C/R engineers give you to help develop pliable parts for your own critical applications. Please write us for your copy of "Engineering with Sirvene."

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Write for Bulletin No. 308

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THIS MONTH'S COVER

Here, away from all machining and grinding operations, is where The Federal Bearing Company calibrates, assembles, tests, cleans, and packs all super-precision ball bearings for military and industrial use. Parts entering the department are checked on air and electronic gages that read in millionths of an inch. Assembled bearings are loaded, tested and checked for noise level, smooth running, and torque in accordance with ball bearing standards and customer specifications. Pictured in this photograph by Sid Karson of McGraw-Hill Studios is the test for "breakaway" torque.

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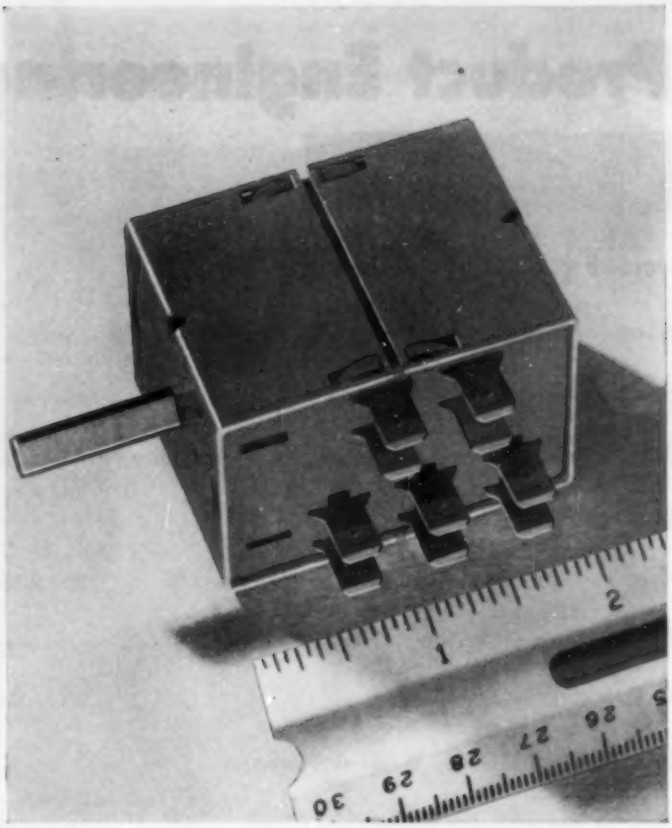
Designed for you...!

Versatile, New Rotary Control Switch



To meet the need of home and commercial air conditioning units for simple, automatic selection, Mallory has developed a completely new switch design. This clean, simple switch design lends itself to a wide variety of multiple circuit switching applications. It embodies these important features:

SINGLE KNOB ROTARY CONTROL—for utmost convenience of user manipulation, and simplicity of product design and assembly.

SMALL, COMPACT CONSTRUCTION—requires minimum space, needs no bulky mounting hardware.

EXTREME FLEXIBILITY—five different cams, each controlling two circuits, and eight possible index positions. Hundreds of switching combinations can be devised. Extended shaft can be supplied for mechanical coupling to shutter control or other related mechanisms.

AMPLE CAPACITY—easily handles 1½ hp., 250-volt motors.

SIDE-LOCATED SPADE TERMINALS—cut your assembly costs, and save valuable space.

The new Mallory switch is competitively priced ... may even cost less per circuit than the switch you're now using. It incorporates the extensive engineering and product experience that we have gained in making millions of timers and switches for the appliance industry. For complete information, and for a detailed discussion of your specific needs, write or call Mallory today.

***Expect more ... Get more from* MALLORY**

Serving Industry with These Products:
Electromechanical—Resistors • Switches • Television Tuners • Vibrators
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MALLORY
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Highlights

When requesting further information from companies and organizations mentioned in the items below, confusion can be avoided by referring to the issue of Product Engineering in which items appear.

METALLIC MATERIALS

. . . . A new mineral, not found in nature, has been produced by subjecting silicon and oxygen compounds to the high pressures and temperatures that exist about 60 miles below the earth's surface. The Norton Co., Worcester, Mass., reports that no use is now foreseen for the mineral. However, its production may yield basic information on how minerals form and what materials might be found at depths not yet reached by scientists in their search for minerals.

HIGH TEMPERATURE ALLOYS . . . .

. . . . High purity chromium may be the key to the development of a whole series of new high temperature alloys. According to the Bureau of Mines research center at Albany, Oregon, pure chromium can be ductile at room temperature and has good high temperature properties. Commercially available chromium is brittle and is usually contaminated with traces of oxygen and water vapor. Presently, to remove these contaminants—as well as measurable quantities of iron, copper, silicon and others—costs $250,000 per lb.

STAINLESS STEEL POWDER . . . .

. . . . A new type of metal powder, called Stain-Alloy, can be used by fabricators of gears, television cores, welding alloys and other electronic and electric parts, says Alloy Metal Powders, Inc., Brooklyn, N. Y. The powder, 18-8 low carbon, is moldable at compacting pressures of 30-50 tons per sq. in. and is claimed to be substantially free from surface oxidation.

ELEMENT 100 . . . .

. . . . Unnamed as yet, element 100, is closely analogous to element 98—erbium—of the rare earth family. University of California scientists report the element to have a mass of 254 and a half life of three hours. The element is reported to have no value in the making of atomic weapons or in the production of atomic power. It is looked upon as important only in physio-chemical research at this time, but other uses may be found.

CORROSION RESISTANT COATING . . . .

. . . . A corrosion resistant alloy coating that imparts the advantages of stainless steel to ferrous material is a development of the New York Testing Laboratories, Inc., New York, N. Y. The coating, it is claimed, resists strong acids and acid gases and increases a material's resistance to salt water. Phosphorous is alloyed with metallic constituents in fairly large percentages of the total composition. The phosphorous lowers the melting point and increases the fluidity of the alloy combination. This permits proper bonding to the base metal at a moderate temperature.

NICKEL LINED PIPE . . . .

. . . . Through the use of new techniques and new plating equipment, steel pipe can now be internally plated with nickel. International Nickel Company, Inc., New York, N. Y., reports that the pipe combines the corrosion-resistance of nickel with the structural strength of seamless pipe and may well be the answer to many corrosion and contamination problems.

NONMETALLIC MATERIALS

. . . . A big market for trimethylolethane (TME) is being forecast, particularly in new types of alkyd resins which are said to be gaining favor as surface coatings for appliances and automobiles. Research labs of the Heyden Chemical Co., New York, N. Y., have cited three advantages for using TME in alkyds: improved color retention, better outdoor durability and better resistance to solvents.

FUEL ADDITIVE . . . .

. . . . A fuel additive that will completely dissolve and remove the carbon, gum and varnish formed in engines is the claim of the Towmotor Corp., Cleveland, Ohio. After removing the carbon and varnish, the additive is said to coat engine surfaces with a microscopic protective film to which gum and carbon cannot adhere. And there's another advantage says Towmotor: It will remove the lead salts that pile up and interfere with the balance of the carburetor.

TITANIUM CARBIDE . . . .

. . . . Titanium carbide in place of brass for rod mill guides has reduced wear by as much as 45 to 1 in the case of rod mills used for 1010, 1020 and other grades of alloy wire rod. Kennametal Inc., Latrobe, Pa., reports a mill yield increase of 2 percent with net

(continued on page 7)

MEMO: To our Advertising Agency
SUBJECT: Could those ads be about us?

Let's face it, fellows! Haven't you been gilding us lilies a bit?

We sweat bullets, sometimes, over moulds. Sometimes we balance off imponderables like material variations, temperature changes, atmospheric conditions and the rest—and get the right answer quick. Sometimes, not so quick. For this moulding business is still almost as much art as science, and there isn't any such thing as heavy-duty, all-weather, push-button perfection.

Admittedly, good equipment and experience like ours means a break for the customer. Which probably explains why we have on our books right now hundreds of customers, big and small, who've stuck with us as principal suppliers for ten years and over.

How about using that fact for an ad—instead of a picture of a plastics application which "Only could be properly produced by K-K, with its mighty resources and unparalleled know-how"?

Try it. Let's see if one or two good new customers don't call us!

Twist-out plug moulded for Bulldog Electric Products —a 10-year-plus K-K customer

KURZ-KASCH

Specialists in Thermo-Setting Plastics for 37 years

Kurz-Kasch, Inc. • 1427 S. Broadway • Dayton 1, Ohio

BRANCH SALES OFFICES: New York, *Mt. Vernon MO 4-4866* • Rochester, *Hillside 4352* • Chicago, *Merrimac 7-1830* • Detroit, *Trinity 3-8200* • Philadelphia, *Hilltop 6-6472* • Dallas, *Logan 5234* • Los Angeles, *Richmond 7-5381* • St. Louis, *Delmar 9577* • Atlanta, *Elgin 0870* • Toronto, *Riverdale 3511.*

EXPORT OFFICE: 89 Broad St., New York City, *Bowling Green 9-7751.*

savings of $2.75 per ton caused by reduced down time for replacement of worn guides. In addition, scrap and maintenance have been reduced, and better cross sectional accuracy and more uniform surface finish of the wire rod have resulted.

OPTICAL CEMENT . . . .

. . . . An optical cement, plasticized cellulose caprate, has been developed by chemists at the Naval Research Laboratory. The new cement is said to be capable of withstanding extreme temperature variations and other rigors of Naval service, and is supposed to be sufficiently fluid to allow it to be cemented at a temperature of less than 250 Fahrenheit.

PLASTIC IN AIRCRAFT . . . .

. . . . Reports from the West Coast indicate an increasing use of glass-fiber-reinforced phenolic plastics for aircraft and missiles. Hughes Aircraft's Culver City, Calif., plant is making extensive use of plastic that can withstand 500 F temperatures on missiles. Their air to air missile, the Falcon, has a plastic fuselage, wing and stabilizer, thus conserving considerable strategic material that otherwise would be needed.

ALL-PURPOSE ADHESIVE . . . .

. . . . Development of a strong, all-purpose adhesive that will withstand a pull of more than 300 lb at temperatures above 300 F is claimed by the Pioneer Latex and Chemical Co., Middlesex, N. Y. The adhesive is reported to be able to adhere to porous and non-porous surfaces, and to serve as a protective coating. It is also said to be heat resistant, corrosion resistant, nonflammable and nontoxic.

PROCESSES

. . . . Lower internal porosity in zinc die castings is one result claimed for a new vacuum die casting method. The Nelmor Corp., Detroit, Michigan, says that the casting method evacuates and seals a standard die cavity before injection of the molten metal. Fewer rejects, higher tensile strengths and greater surface hardness are claimed. Reduced internal porosity plus the increase in hardness and strength of the cast part should enlarge the die casting field.

MACHINING AL AND MG . . . .

. . . . Smooth operation (with as little vibration as possible) and high speeds are essential to good machining of aluminum and magnesium. So says the Carboloy Department of General Electric, Detroit, Mich., which adds that keen cutting edges, smooth tool surfaces and plenty of clearance for chips are also required. Roughing calls for a moderate-to-high speed and heavy cuts and feeds; finishing demands higher speeds and lighter cuts and feeds. And lots of cutting fluid should be used, particularly with magnesium which must be cooled to prevent igniting the chips.

CORROSION PREVENTION . . . .

. . . . A preservative process involving electrolysis is being used to reduce corrosion on reserve vessels anchored in salt water. The process, developed by the General Electric Co., Schenectady, N. Y., is estimated to be saving the government $3,250,000 per year. Rectifiers, it is reported, set up a d-c voltage between the submerged portion of the ship and the water, preventing the ship bottoms from rusting.

GERMANIUM REFINING . . . .

. . . . A new and simple method for refining germanium and other materials to practically perfect purity has been developed at the Bell Telephone Laboratories. Bell's claim for the process: only one atom of impurity in ten billion atoms of the material. The new technique is called zone-melting, and is being used to refine a wide variety of materials other than germanium, such as metals, other semi-conductors, and various organic and inorganic substances.

COMPONENTS

. . . . An instrument that makes possible the continuous control of mixture in a stream of multi-component gases or light liquids has been perfected by the General Electric Co., Schenectady, N. Y. An ion resonance mass spectrometer uses an electron beam to shatter molecules into ions; a radio-frequency signal then sorts ions and separates them on to a chart by electrical impulse. Instrument is designed as a primary sensing device whose signal can be used to set in motion a battery of computers and other automatic machines for complete process control.

IMPULSE VOLTMETER . . . .

. . . . An impulse vacuum tube voltmeter is said to be simpler and faster than oscillographic recording. Designed by scientists at the Naval Research Laboratory, the instrument is used to measure peak values of transient waves, including electrical, explosion pressure, sonic and acoustical shock waves.

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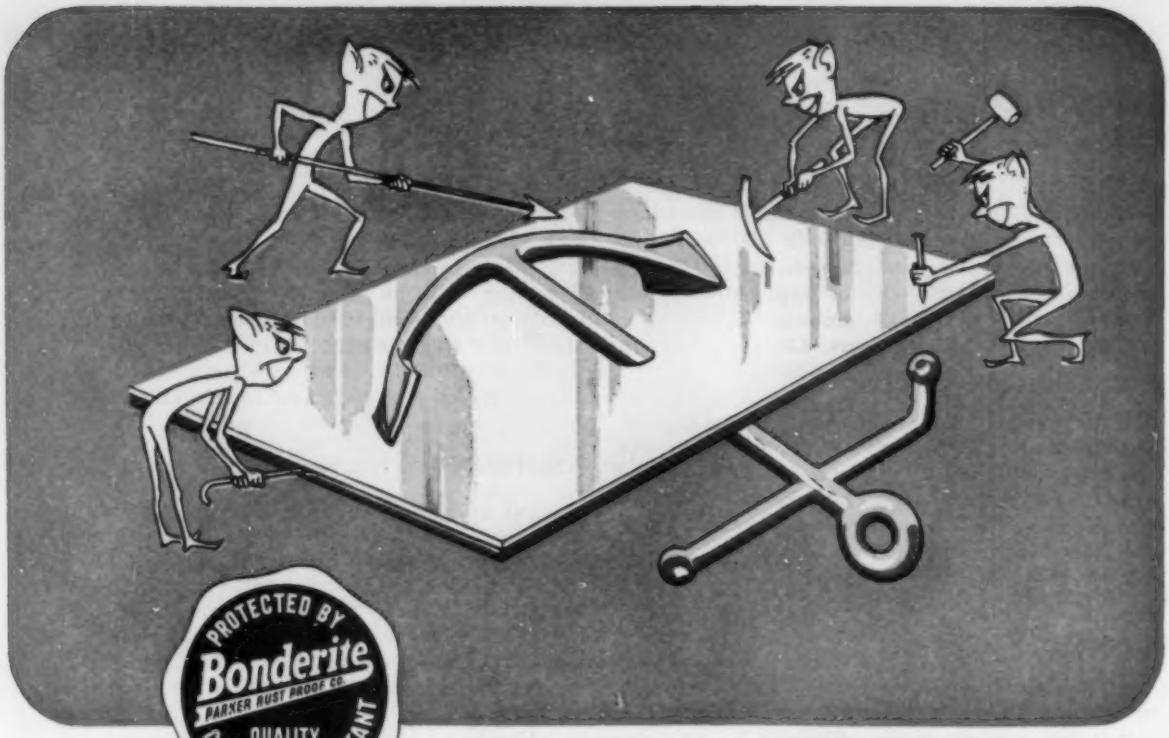
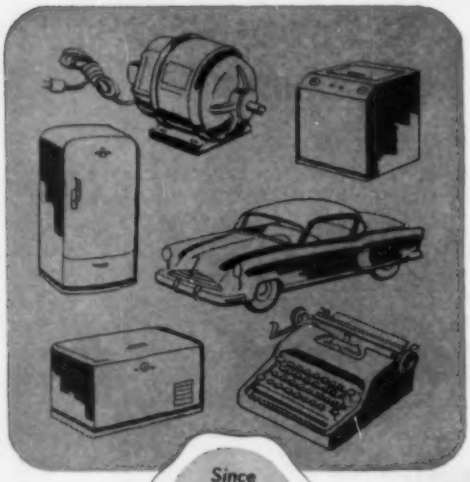


Anchors paint to metal!



Since 1915— leader in the field

● Even the best paint needs help to stick to metal surfaces. It needs Bonderite to supply a secure anchor.

Bonderite creates a nonmetallic phosphate coating integral with metal surfaces. This coating provides a lasting bond between paint and metal. Because it is nonmetallic, it resists corrosion, preventing moisture penetration and peeling, confining finish damage through scratch or bump to the site of the paint film break.

Bonderite, standard corrosion resistant paint base treatment throughout the world, makes it possible for paint to perform its functions of protection and fine appearance through years of hard service.

Your products should have Bonderite under the paint. Get the facts on Bonderite's efficiency, economy and dependability. Write today!

**Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.*

Parker RUST PROOF COMPANY
2179 E. Milwaukee, Detroit 11, Michigan

BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces

Highlights ~

ELECTRIC CLUTCH . . . .

. . . . A clutch that operates from a push button control is being developed for applications in the aviation, automotive and communication industries. The Warner Electric Brake and Clutch Co., Beloit, Wis., reports that the clutch consists of an iron disk attached to the motor and an electromagnet attached to the drive shaft. When current is passed through the magnet, the disk is attracted and engaged. A varying degree of clutch engagement is possible by simply varying the amount of current to the magnet.

RECTIFIERS DISPLACE M-G . . . .

. . . . Rectifiers are displacing motor-generator sets, because of their high power, ease of repair, silent operation and other characteristics. The U. S. Navy reports that with the introduction of germanium and selenium rectifiers it was found that rectifiers were more suitable for a-c to d-c conversion aboard Navy vessels. One of the biggest advantages is that any required number of disks or plates can be easily assembled to make up a rectifier unit for any amount of d-c power that may be required by the ship.

X-RAY QUANTOMETER . . . .

. . . . An instrument for rapid chemical analysis of materials by X-ray fluorescence, has been developed by the Allied Research Laboratories, Glendale, Calif. The instrument is said to perform non-destructive analysis of metals, powders and liquids, with no deformation of the material being analyzed. Among applications listed are the determinations of elements present in ores, slags, metals, many chemical compounds and additives for petroleum products.

TESTING

. . . . A new hydraulic facility, available to industry for research problems involving pressures above the capacity of present equipment or for high pressure gage calibration, has been installed at the University of Detroit. The equipment can be used for pressures up to 25,000 pounds per square inch gage.

ELECTRONIC NOISE ABSORBER . . . .

. . . . An electronic noise-absorbing device has been developed that reduces the volume of low-frequency sounds before they reach the human ear. The Radio Corporation of America reports that the unit is too primitive as yet for industrial or home use. The experimental device consists of a microphone and loudspeaker. The microphone picks up any movement of air corresponding to a sound and sends an electric signal to the loudspeaker. The speaker sends out a sound—a movement of air—that nullifies the original air movement. The result: a reduction in sound in the immediate area of the speaker.

HIGH TEMPERATURE HAFNIUM . . . .

. . . . Tests on pure isotopes of hafnium and zirconium have indicated that heat resistant ceramics made of pure hafnium can take 1,700 C without cracking, while similar parts of pure zirconium can take only 1,000 C. The Oak Ridge National Laboratory, Oak Ridge, Tenn., has been studying zirconium for heat resistant structures. Since the elements occur together and separation is almost impossible, the new knowledge tends to prove that hafnium probably helps to stabilize zirconium at high temperatures.

RADIATION LABORATORY . . . .

. . . . To study the application of radioactive isotopes to the solution of various industrial problems, new facilities are being built by G.E. Co., Schenectady, N. Y. Activities planned for the center include development, testing and application of various types of particle accelerators; studies of radiation damage; development of radiation shielding; development of neutron activation analysis; techniques; and calibrating of various radiation instruments.

PAINT RESEARCH . . . .

. . . . A new method of measuring chemical conversions that take place in pretreatments used as paint bases for steel surfaces has been devised from experiments at New York University's College of Engineering. The method: measuring—through loss of electrical resistance—the transfer of water soluble matter from the pretreated surface. The claim: an organic coating applied over the base will become more durable if the chemical pretreatment base can be made as insoluble as possible. The possibilities: Longer paint life and better protection.

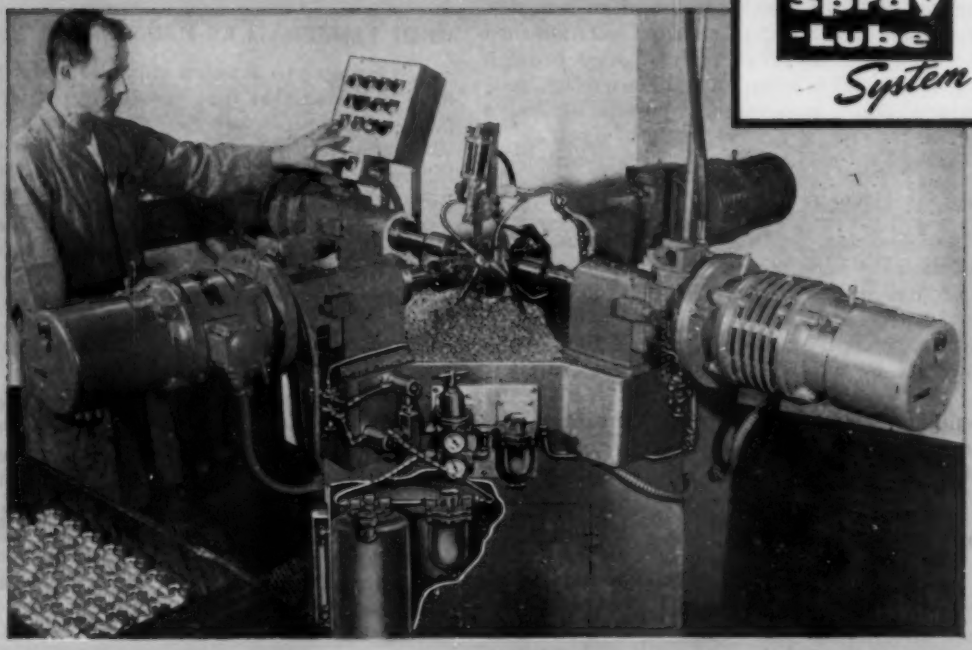
SALT SPRAY TEST . . . .

. . . . Discussion of the present salt spray test (B117) of the ASTM has brought forth recommendations for changes that have the approval of other interested groups. As a result of extensive cooperative tests it has been recommended that the present 20 percent salt solution be replaced by a 5 percent solution. In addition, a new tentative specification is to be proposed embodying the acetic acid modification of the salt spray test. But before any new specifications can be accepted, approval of all interested groups is needed.

NOW

a quick, low-cost way to "tool-up" for bigger production

NEW *Norgren* **Spray -Lube** *System*



gives more efficient application of cutting oils for

- ***higher cutting speeds***
- ***faster rate of feed***
- ***longer tool life***
- ***lower unit production costs***

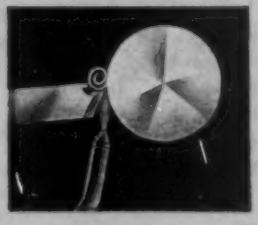
on tapping machines, drill presses, milling machines, grinders, lathes, boring machines, high-speed saws, stamping presses, deep draw presses.

SEE IT AT THE ASTE SHOW

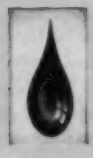
PIONEER AND LEADER IN OIL FOG LUBRICATION FOR 26 YEARS

• VALVES • FILTERS • HOSE ASSEMBLIES
• REGULATORS • LUBRICATORS

C. A. *Norgren* CO.
3428 So. Elati, Englewood, Colo.



Coolant where you need it... spray is applied to work area from any required direction to thoroughly lubricate critical areas of contact between cutting tool and work piece.

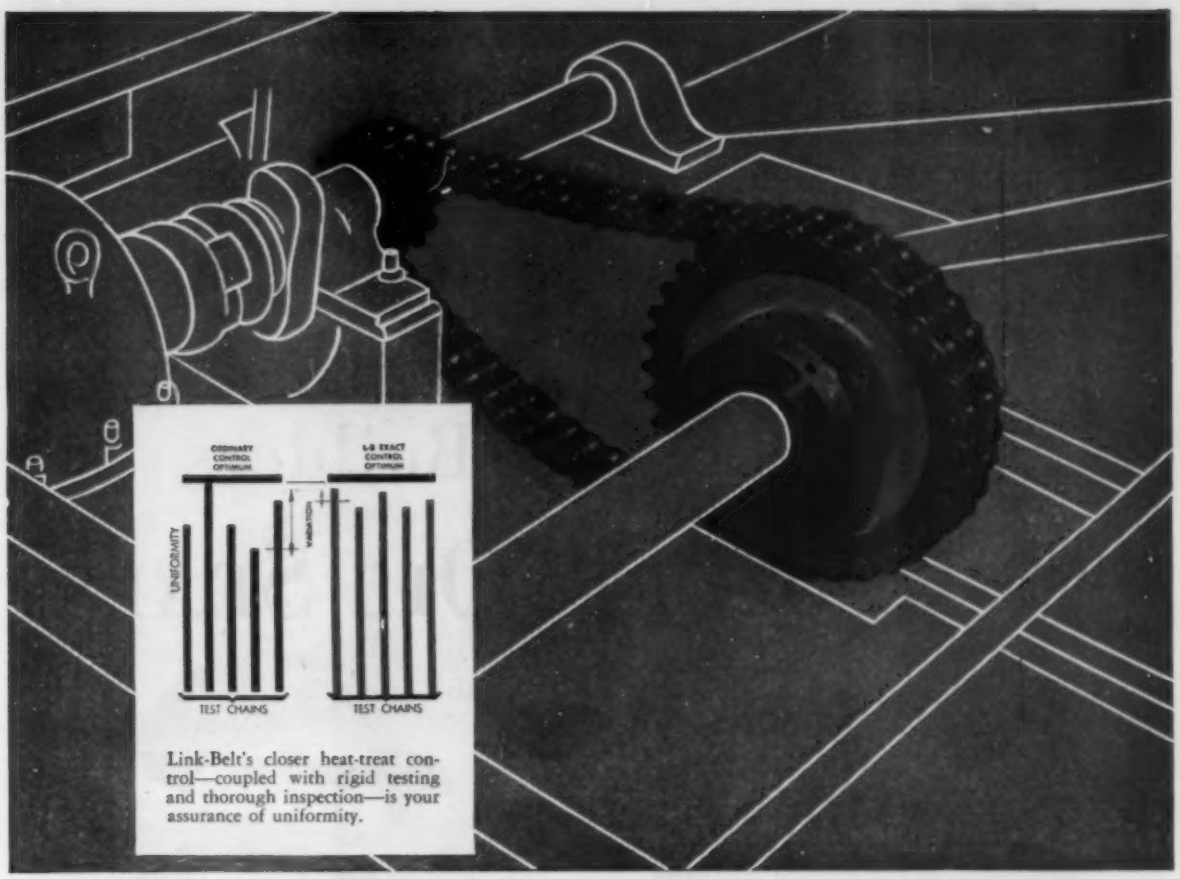


A Drop of Coolant

A Drop of Coolant SPRAYED

Fine spray rapidly dissipates heat... the spray lubricates tool more efficiently; has greater exposed oil surface area for fast, thorough dissipation of heat.

WRITE FOR COMPLETE DATA—NEW FOLDER No. 491



Link-Belt's closer heat-treat control—coupled with rigid testing and thorough inspection—is your assurance of uniformity.

Closer heat treat control means longer roller chain life!

But it's only one of many engineering extras you get from LINK-BELT

THE long-life record of Link-Belt Precision Steel Roller Chain is based on more than closer heat treat control. Consider such extra-wear features as shot-peened rollers and lock-type bushings. They're further assurance of Link-Belt's *built-in* extra life.

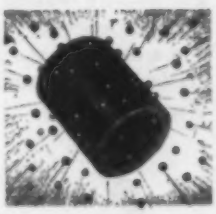
Link-Belt Roller Chain is available in single or multiple widths, ⅜" through 3" pitch. Double pitch, 1" through 3". For all the facts, call the Link-Belt office near you today, or write for Data Book No. 2457.

LINK-BELT

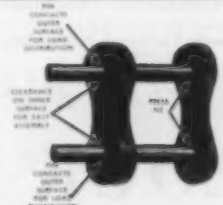
ROLLER CHAIN & SPROCKETS

LINK-BELT COMPANY: Plants: Chicago, Indianapolis, Philadelphia, Colmar, Pa., Atlanta, Houston, Minneapolis, San Francisco, Los Angeles, Seattle, Toronto, Springs (South Africa), Sydney (Australia). Sales Offices, Factory Branch Stores and Distributors in Principal Cities. 13,120

Don't overlook these other LINK-BELT extras



Shot-peened rollers have extra fatigue life for higher speeds, heavier loads.



Couple, uncouple multiple-width chains easily.

Lock-type bushings assure free articulation.

This symbol identifies the National Machine Tool Builders' Association—a group of 196 manufacturers of machine tools. 148 of these companies, or 3 out of 4, are using Garlock KLOZURE Oil Seals.

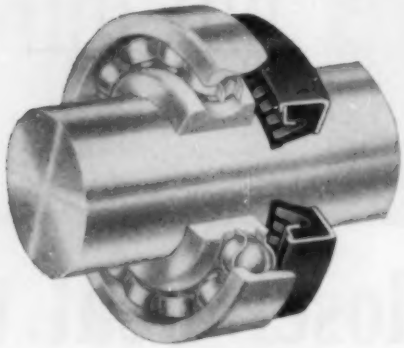
3 out of 4

Machine Tool Builders use KLOZURE* OIL SEALS

Here are 3 reasons why–

1. The KLOZURE Oil Seal is a precision-made product, so necessary for all components of the tools which are designed for fine precision machining.
2. KLOZURES are *uniform*—both in sealing contact and in spring load.
3. KLOZURE Oil Seals are extremely *efficient*—they provide effective sealing with a minimum of power loss and heat generation.

For positive bearing protection specify KLOZURE Oil Seals for your machinery. KLOZURES are made in many models and a complete range of sizes. Get all the facts—call your Garlock representative or write for KLOZURE Catalog No. 10.



Model 53 finger spring KLOZURE, for normal and high speed service, applied to a shaft to protect the ball bearing.

Model 31 — A general purpose finger spring seal for medium speeds.

Model 63 — A general purpose finger spring seal for normal and high speed service.

Model 65 — A general purpose garter spring seal for normal and high speed service.

THE GARLOCK PACKING COMPANY, PALMYRA, NEW YORK

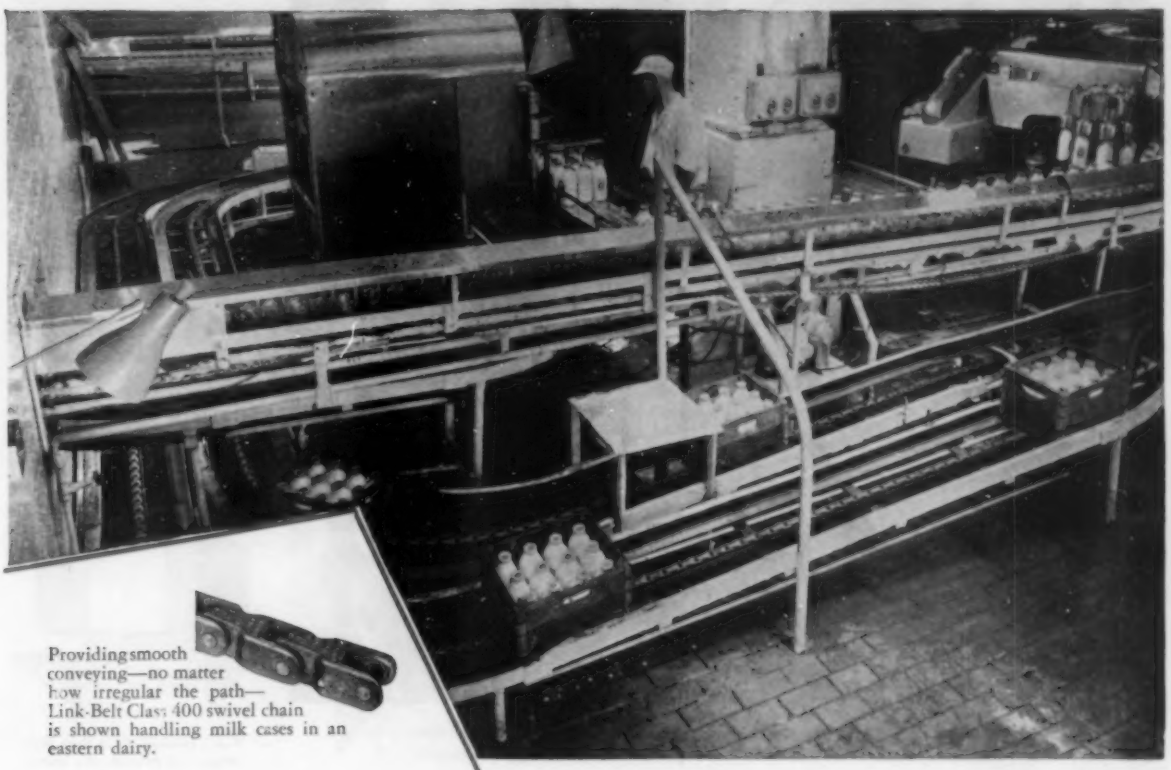
Sales Offices and Warehouses: Baltimore • Birmingham • Boston • Buffalo • Chicago • Cincinnati • Cleveland • Denver Detroit • Houston • Los Angeles • New Orleans • New York City • Palmyra (N. Y.) • Philadelphia • Pittsburgh • Portland (Ore.) • Salt Lake City • San Francisco • St. Louis • Seattle • Spokane • Tulsa.

In Canada: The Garlock Packing Company of Canada Ltd., Toronto, Ont.

*Registered Trademark

GARLOCK PACKINGS, GASKETS, OIL SEALS, MECHANICAL SEALS, RUBBER EXPANSION JOINTS

Around corners . . . over vertical curves--
Link-Belt swivel chain assures smooth travel



Providing smooth conveying—no matter how irregular the path—Link-Belt Class 400 swivel chain is shown handling milk cases in an eastern dairy.

No ONE chain serves every purpose — choose the right one from the complete line

Class RC universal crescent flat-top chain can be used for multiplane operation traveling variety of paths.

Class RC flat-top chain —precision made for smoothest, spill-free carrying and long life.

S-815 flat-top conveyor chain — economical, sturdy, reliable, easy to detach and to keep clean.

Class RC crescent flat-top chain — travels in horizontal planes, around corners; ideal for bottles and cans.

LINK-BELT offers the chain that's best for every job

HERE'S an economical conveyor chain that's widely used for moving cases, cartons, cans, etc. In addition to its horizontal and vertical flexibility, this Link-Belt swivel chain can be assembled or uncoupled without the aid of tools.

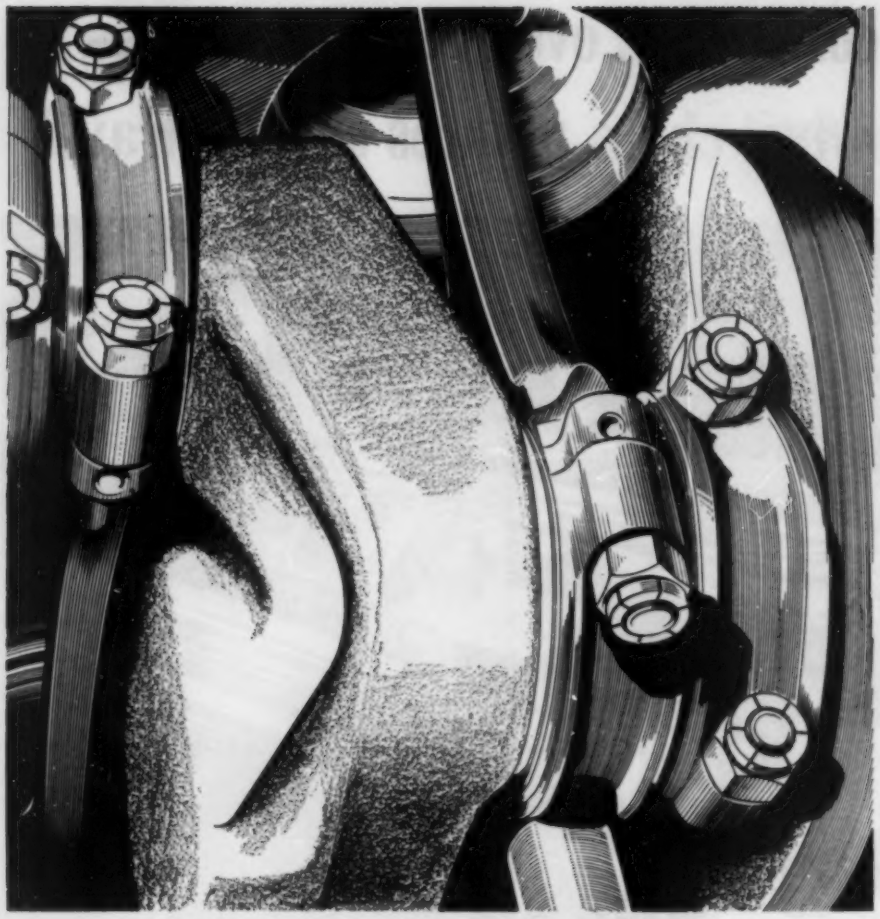
Manufacturing refinements such as these are typical of every chain in the complete Link-Belt line. Accurate control of raw materials and manufacturing processes is your assurance of uniformity, longer life.

For complete information on chains and sprockets for conveying or drive service, see your Link-Belt sales representative. He can show you the *one* chain that's best suited to your exact requirements.

LINK-BELT

CHAINS and SPROCKETS 13,500

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.



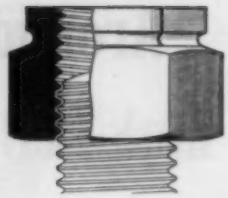
More and more automotive repair shops and industrial plants are turning to FLEXLOCs to reduce maintenance on high speed, vibrating equipment.

FLEXLOC locknuts save $600 per year in reconditioning automobile engines

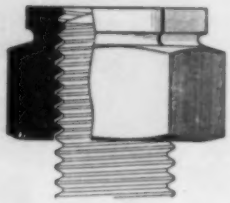
By using FLEXLOCs on connecting rod bolts, a motor reconditioning shop cut assembly time by a minimum of 5 minutes per motor. This added up to a yearly saving of 250 hours or $600. No drilling of bolts was needed . . . no adjusting of nuts to set cotter pins was required. And the FLEXLOCs assured a tighter assembly than was possible with the castellated nuts and cotter pins formerly used.

FLEXLOC locknuts reduce maintenance too. Once they are installed, you can forget them. Service and inspection periods can be stretched safely from days to weeks. And FLEXLOCs are reusable. They can be applied again and again without losing locking efficiency.

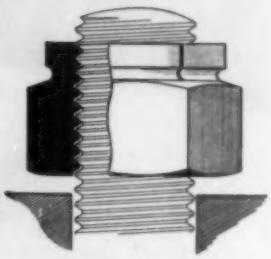
You can get FLEXLOC Self-Locking Nuts of various types and materials in a wide range of sizes and in any quantity. These one-piece, all-metal nuts are carried in stock by leading industrial distributors everywhere. Write for literature and samples for test purposes. STANDARD PRESSED STEEL Co., Jenkintown 28, Pa.



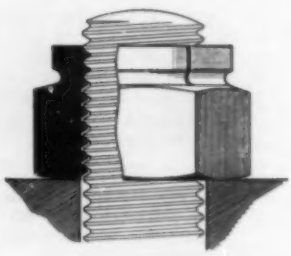
Starting. A FLEXLOC starts like any ordinary nut. Put it on with your fingers. Tighten it with a standard hand or speed wrench.



Beginning to Lock. As the bolt enters the segmented locking section, the section is expanded, and the nut starts to lock.



Fully Locked As a Stop Nut. When 1½ threads of a standard bolt are past the top of the nut, the FLEXLOC is fully locked. A FLEXLOC does not have to seat to lock.



Fully Locked As a Seated Nut. When it is used as a lock or stop nut, the locking threads of the FLEXLOC press inward against the bolt, lifting the nut upward and causing the remaining threads to bear against the lower surface of the bolt threads. Vibration will not loosen a FLEXLOC, yet there is no galling of threads.

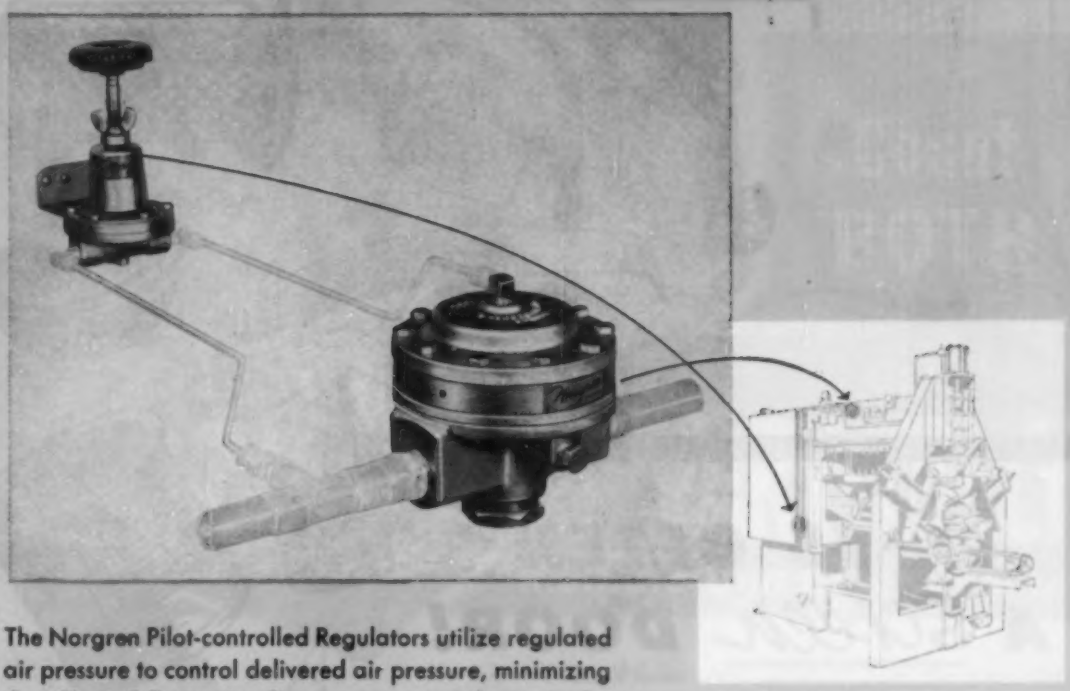
FLEXLOC® LOCKNUT DIVISION

SPS
JENKINTOWN PENNSYLVANIA

Norgren PILOT-CONTROLLED REGULATORS

give

- extreme precision in air control
- flexibility and convenience with remote control



The Norgren Pilot-controlled Regulators utilize regulated air pressure to control delivered air pressure, minimizing the effect of fluctuating line pressure as a factor in delivering uniform working air pressures. No heavy adjusting springs . . . adjustment is easy and precise.

Remote control unit provides maxium flexibility and efficiency in machine design and plant layout . . . Pressure regulator can be placed where it is most effective, and pilot control regulator installed at most convenient location.

Available in ½", ¾", 1" sizes in both remote control and integral types for 2 psi to 120 psi delivery pressure.

PIONEER AND LEADER IN OIL-FOG LUBRICATION FOR 26 YEARS

- Valves
- Filters
- Regulators
- Lubricators
- Hose Assemblies

WRITE NOW FOR NEW CATALOG No. 600

C. A. Norgren CO.
1428 SO. ELATI ST., ENGLEWOOD, COLO.

THE DOOR TO BETTER PRODUCT *performance*

IS OFTEN A *screen* DOOR!

You don't *see* the industrial wire cloth in every motor car and truck. But, it's there. In the small parts—to make them *big* in performance. In air cleaners, brake lining, oil and fuel strainers, and so on.

And, if it's Reynolds, it's *the* wire cloth that gives superior service satisfaction. It puts precision performance in precision parts.

From metal to mesh . . . from wire to weave . . . from ductility to durability . . . Reynolds is the wire cloth of precise specifications—*your* specifications.

Reynolds 60-year-long experience can match your wire cloth needs. Because Reynolds has progressed with the automotive industry—and all industries, from agricultural to home appliance applications.

Consult Reynolds engineers . . . no cost . . . no obligation

Reynolds WIRE CLOTH for Industry

NS NATIONAL-STANDARD Company NILES, MICHIGAN

REYNOLDS WIRE DIVISION, NATIONAL-STANDARD CO., Box 200, **DIXON, ILL.**

Divisions of National-Standard Co.

ATHENIA STEEL...*Clifton, N. J.*.....Flat, High Carbon, Cold Rolled Spring Steel
NATIONAL-STANDARD...*Niles, Mich.*.....Tire Wire, Fabricated Braids and Tape
WAGNER LITHO MACHINERY...*Jersey City, N. J.*.....Metal Decorating Equipment
WORCESTER WIRE WORKS...*Worcester, Mass.*...Round and Shaped Steel Wire, Small Sizes

Fast Movers or Shelf Warmers?

Count BOTH

(and 1,001 Other Items)

WITH

VARY-TALLY

Multiple-Unit Reset Counter

How Can the Vary-Tally count for you? Write for news sheet and prices.

Vary-Tallies help you separate the sheep from the goats, the big ones from the little ones, the red ones from the green ones — in manufacturing, sales, accounting, researching and what not!

Vary-Tallies will do *any* counting job you want in any combination up to 6 banks high, 12 units wide (with a minimum of 12 units wide). Yes, you can count on 'em or with 'em *to your profit* — note these features of construction:

- **Easily Readable from Any Angle . . . Bold figures Always Centered in Window . . . No Glare . . . Figures not Covered by Fingers in Operation**
- **Easily Portable, yet Ruggedly Built for Long Wear**
- **All Parts Corrosion-Resistant; Working parts of Hardened Steel**
- **Separate Counting Units Can be Rotated like Tires on a Car, to Distribute Wear Evenly**
- **Not Affected by Extreme Heat or Cold**
- **Individual Tag Above Each Counter-Window — Not Strip Tabs**
- **Veeder-Root Quality in Every Part**

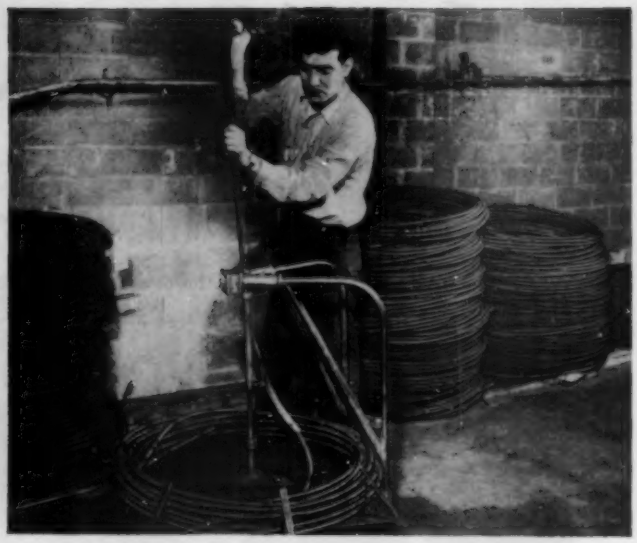
"The Name that Counts"

VEEDER-ROOT INC.

HARTFORD 2, CONNECTICUT

Chicago 6, Ill. • New York 19, N. Y. • Greenville, S. C. • Montreal 2, Canada • Dundee, Scotland • Offices and Agents in Principal Cities

1. **THESE LARGE REELS** of steel wire are manufactured to the exact specifications of the Roto-Rooter Corporation. Here Roto-Rooter employee Glen Anderson operates an electric hoist to transfer a reel of wire to the coil forming machine, where it is formed into one of the various sizes of flexible cable used in the Roto-Rooter machines.



2. **ILLUSTRATED HERE** is the coiling machine which is used to place the bulk cable coming from the coiling machine into the Roto-Rooter machine reels.

"That AS&W wire is really wire!"

says R. A. YOUNG,

Secretary of the Roto-Rooter Corporation, Des Moines, Iowa

"Our business is making machines*—a special sewer and drain-cleaning machine called the Roto-Rooter. Strict specifications are followed in the manufacture of the Roto-Rooter, especially in the flexible steel cable which is the heart of the machine. That cable must be really tough — strong enough to withstand the acute twisting action of the revolving reel, flexible enough to negotiate the sharpest bends and turns, highly resistant to the corrosive elements found in all sewers. That cable absorbs a terrific beating, and naturally it must be fabricated from an especially high grade steel wire.

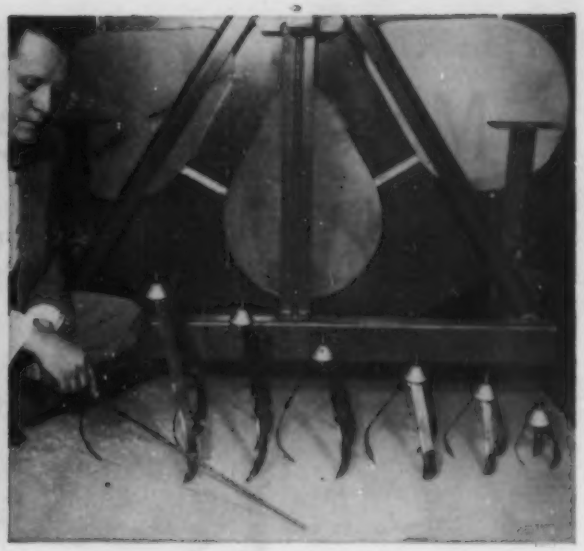
"We found the kind of wire we need at American Steel & Wire. Our engineers got together with the AS&W metallurgists, working out the heat treating and hardness specifications. The wire we get from AS&W is made especially for us, and is not used by any other manufacturer. One of the things we like best about AS&W is their constant adherence to our close-tolerance specifications. And we're more than satisfied with the terrific performance of the steel wire in our machines. That AS&W wire is *really* wire!"

* * *

The experience of the Roto-Rooter Corporation is not unusual. Thousands of manufacturers all over the country have learned to depend on the consistently high quality of USS American Manufacturers Wire. A better-grade steel wire enables you to do a better fabricating job . . . and often saves you money, too.

American Steel & Wire carries, *in stock*, over 400 different types of American Manufacturers Wire, including Stainless, for you to choose from. For special requirements, our trained staff will work with you to develop a new wire that will meet your specifications exactly. Why not let us help you with *your* steel wire problems? If you make it of wire, make it of the best—USS American Manufacturers Wire.

3. EMPLOYEE J. B. THOMAS is shown attaching the steel cutting blades to flexible steel cable on the Roto-Rooter machine. The revolving reel shown on the right housed 120' of this 3/4" AS&W steel cable. In the background can be seen the stockpile of finished cables ready for installation in the machine.



4. H. W. LARSEN of the Roto-Rooter Corporation shows the various sizes of Roto-Rooter cutting blades. In operation, the blades are attached to the end of the flexible cable and receive their cutting motion from the revolving reel at the opposite end through the steel cable.

5. AND HERE'S a finished Roto-Rooter in operation with the cutting blades about to be inserted into the sewer line. The razor sharp, high-speed rotating blades cut all roots, grease, scale, and other debris into tiny pieces, leaving the line as clean as the day it was installed. The specially-designed steel cable has to absorb a terrific beating in negotiating the sharp turns and bends found in domestic sewer lines—as high as four or five 90° turns in one operation. It's easy to see why the Roto-Rooter Corporation insists on the highest standards of quality in the steel wire they use in these cables . . . and why they use American Manufacturers Wire exclusively.

*Roto-Rooter is a nationwide sewer service and Roto-Rooter machines are placed only on an exclusive franchise basis.

If you make it of wire...
make it of the best!

U S S AMERICAN MANUFACTURERS WIRE

USS

AMERICAN MANUFACTURERS WIRE

AMERFINE—*High-quality fine wire.*

AMERSPRING—*music steel spring wire.*

AMERLOY—*alloy heading wire.*

AMERTEMP—*heavy-duty oil-tempered wire.*

AMERHEAD—*uniform heading wire.*

AMERSTITCH—*extra-tough metal stitching wire.*

AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL CORPORATION, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA., SOUTHERN DISTRIBUTORS · UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

More than one billion hours of

ATLAS SERVICE

powered by

HOOVER

Again, it's Hoover!

Over the past 16 years, Hoover has been the prime source for electric motors for the Atlas Press Company. Atlas has used more than 400,000 Hoovers—for a total of more than one billion hours of successful service—in both industrial and woodworking tools. Above is one of the newest applications, an exceptionally accurate and dependable Atlas woodworking saw.

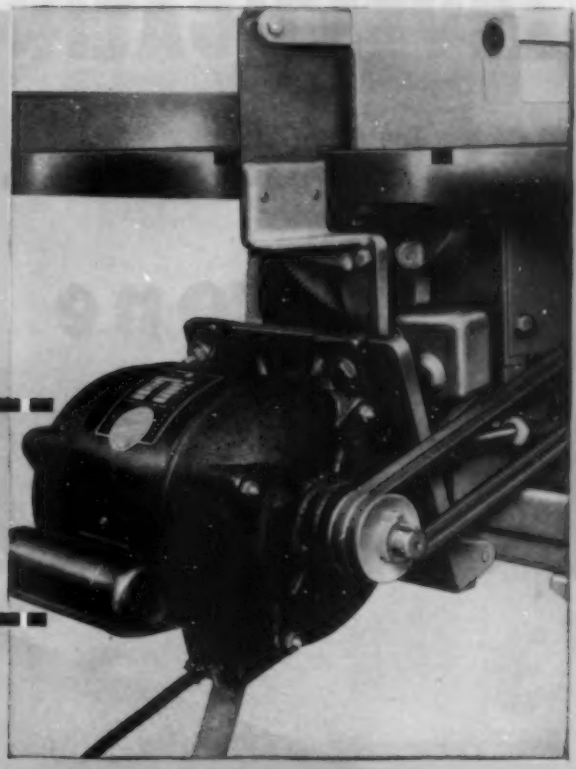
...because Hoovers save space!

Atlas needs reserve power, heavy-duty motors so compact that the same one can be used on several machines. *Only 14 Hoover motors meet every requirement normally encountered in all Atlas machine and power tool installations.* This means minimum inventories for Atlas and Atlas distributors, and it means instant availability from a local source for users.

...because they can take it!

Atlas engineers say "Hoover motors give us the dependability we require for abusive, 8-hour-a-day industrial use. In most instances, because of limited space, there is no special protection. Motors are constantly exposed to abrasive dust, grit and metal shavings. Hoover motors operate efficiently under the most adverse conditions. Our records prove it!"

PRODUCTION FOR HOME AND DEFENSE—Week in and week out, Hoover is producing a very substantial volume of essential materials for the Armed Forces.



The new Hoover-powered Atlas 3021—a big-capacity 8" saw—and a close-up of the motor mount. Note the combination of a Hoover motor and double V-belts for positive drive.

MOTORS

...and they're vibration-free!

"The rigid base and vibration-free operation of Hoover motors," Atlas points out, "are important factors in the accuracy of our heavy-duty, precision tools. Hoover motors help minimize over-all vibration, enabling close tolerance, precision work. We know, from a billion hours of experience, these motors are ideally suited to power our machine and woodworking tools."

FOR EVERY ELECTRIC MOTOR NEED UP TO 5 HP

Send this coupon now for a free copy of the current Hoover catalog listing dozens of low-cost, in-production models in stock or available on short notice. Or set up a meeting with Hoover engineers, who will work with your engineers to tailor-make your motor to your most exacting mechanical and electrical details. No obligation, of course.

HOOVER

THE HOOVER COMPANY, ELECTRIC MOTOR DIVISION
89 BROOK AVENUE, NORTH PLAINFIELD, N. J.

Please send me further information on Hoover Motors. I am particularly interested in motors for

_____
(Indicate type of equipment)

Name _____

Company _____

Address _____

City _____ Zone _____ State _____

WORTH INVESTIGATING! THE PROCESSORS REVEALED IN

Firestone

EXON 654

NEW OPPORTUNITIES FOR

Let us send you a sample of this new plastisol resin that needs no grinding!

Be sure to visit the Exon booth at the forthcoming shows:

Space 341

Space 128

PHYSICAL PROPERTIES OF
EXON 654

Readily dispersed in plasticizer by simple stirring—no grinding necessary.

Form	**Fine White Powder**
Specific Gravity	**1.40**
Average Relative Viscosity	**2.65**

Firestone research has thrown a new light on resins. New **Exon 654** is a remarkably versatile plastisol resin that needs no grinding!

To provide a resin suited to the industry's specialized requirements, Firestone developed **Exon 654** to lend superior paste viscosity stability—physical toughness, chemical stability and heat and light stability to the final product.

Let us send you a sample of **Exon 654** for any application that calls for coating fabrics ...paper...dip coating, slush molding, foaming operations or casting thin films.

For complete information on **EXON 654** or any other resin in the extensive Firestone EXON line, write or phone...

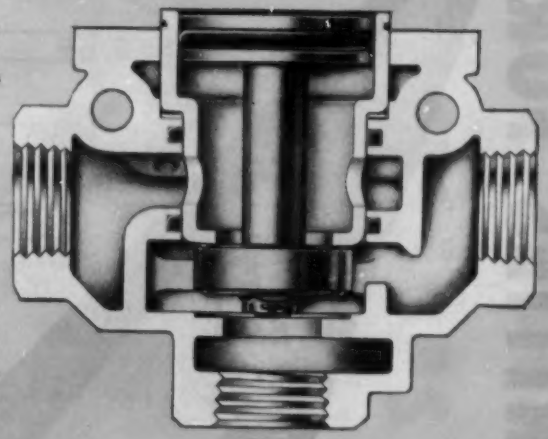
CHEMICAL SALES DIVISION

FIRESTONE PLASTICS COMPANY, Dpt. 23P, **POTTSTOWN, PA.**

Division of The Firestone Tire & Rubber Company

HERE'S HANNIFIN'S *P-M Pilot-Master* VALVE LINE!

The Most Versatile Family of Valves Ever Designed and Built for the Directional Control of Air!



Everything you need from the simplest to the most complicated air-operated circuit can be accomplished with these valves. Included are 2-Way, 3-Way and 4-Way Master Valves and solenoid Pilot-Master Valves...direct-operated 3-Way Pilot Valves in a wide choice of operating heads...and a brand-new series of small direct-operated 4-Way valves. Plan now to get acquainted with these fast-acting, full-area control valves...there's a Hannifin representative near you who will introduce you to their many money-saving advantages.

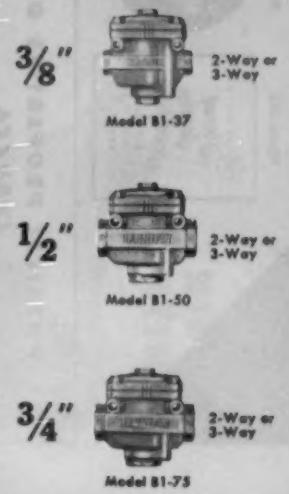
P-M Pilot Valves

Direct-operated 3-Way ¼" (⅜" tapping optional) poppet-type valves for use as "pilot" valves for remote control of P-M Master Valves or direct control of small cylinders.

C1-25 Solenoid Spring Return
C5-25 Hand Locking
C4-25 Hand Non-Locking
C9-25 Palm Button
C7-25 Foot Locking
C6-25 Foot Non-Locking
C2-25 Cam Roll Type
C8-25 Toggle Operated
C9-25 Over-Riding Cam Type
C10-25 Pressure Operated
C13-25 Cam Roller Type
CS1-25 Sequence Valve

P-M Master Valves
Pressure operated

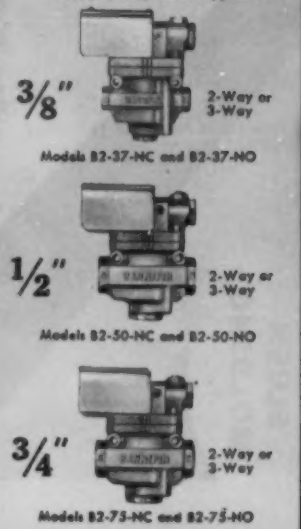
For remote control from a 3-Way P-M Pilot Valve. Series B-1, 2-Way and 3-Way; Series BB-1, 4-Way.



⅜" 2-Way or 3-Way — Model B1-37
½" 2-Way or 3-Way — Model B1-50
¾" 2-Way or 3-Way — Model B1-75

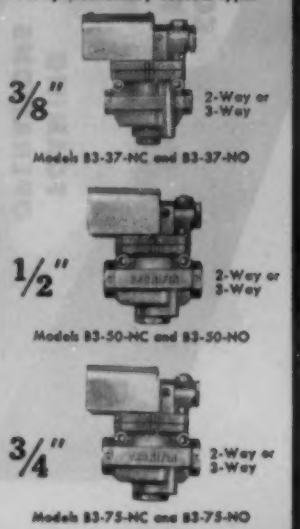
P-M Pilot-Master Valves
Solenoid-controlled by integral pilot heads...

Series B-2, 2-Way and 3-Way spring return type; Series BB-2, 4-Way spring return type.



⅜" 2-Way or 3-Way — Models B2-37-NC and B2-37-NO
½" 2-Way or 3-Way — Models B2-50-NC and B2-50-NO
¾" 2-Way or 3-Way — Models B2-75-NC and B2-75-NO

Series B-3, 2-Way and 3-Way pressure return type; Series BB-4, 4-Way momentary contact type.



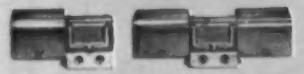
⅜" 2-Way or 3-Way — Models B3-37-NC and B3-37-NO
½" 2-Way or 3-Way — Models B3-50-NC and B3-50-NO
¾" 2-Way or 3-Way — Models B3-75-NC and B3-75-NO

Basic P-M Advantages

- **Removable cartridge contains piston-poppet. Only moving part of main valve. Springless. Replaceable without disturbing main piping. Two cartridge sizes fit all five valve sizes.**
- **2-Way and 3-Way valves operate N.O. (normally open) or N.C. (normally closed). Buy them either way or convert them on the job.**
- **Interchangeable: Same head fits every size valve body in any given series. Same body fits three different heads in every pipe size.**
- **Snap action. Speeds of 600 cycles per minute entirely practical with solenoid models.**
- **For any pressure from 15 to 150 p.s.i., gas or air. Higher pressures permissible when water or oil is the fluid.**

P-M Direct-Operated 4-Way Valves

Direct-operated 4-Way ¼" (⅜" tapping optional) poppet-type valves for control of small double-acting cylinders.



CC1-25 Solenoid Spring Return

CC11-25 Solenoid Momentary Contact

CC2-25 Cam Ball Type

CC4-25 Hand Non-Locking

CC5-25 Hand Locking

CC7-25 Foot Locking

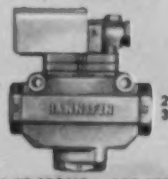
CC6-25 Foot Non-Locking

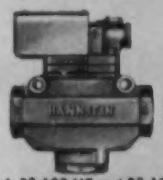
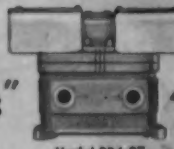
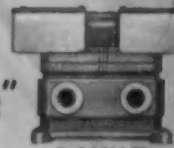
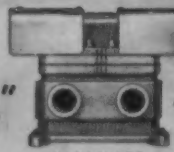
CC10-25 Pressure Operated

P-M Pilot-Master Dual 3-Way Valve

Two 3-Way Pilot-Master Valves mounted in common body. Both pilot valves and main valves pneumatically interlocked so unit "fails safe." For completely safe operation of mechanical presses. ⅜" and 1¼" sizes.

1"		2-Way or 3-Way	Model B1-100
1¼"		2-Way or 3-Way	Model B1-125
⅜"		4-Way	Model BB1-37
½"		4-Way	Model BB1-50
¾"		4-Way	Model BB1-75

1"		2-Way or 3-Way	Models B2-100-NC and B2-100-NO
1¼"		2-Way or 3-Way	Models B2-125-NC and B2-125-NO
⅜"		4-Way	Model BB2-37
½"		4-Way	Model BB2-50
¾"		4-Way	Model BB2-75

1"		2-Way or 3-Way	Models B3-100-NC and B3-100-NO
1¼"		2-Way or 3-Way	Models B3-125-NC and B3-125-NO
⅜"		4-Way	Model BB4-37
½"		4-Way	Model BB4-50
¾"		4-Way	Model BB4-75

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BOOTH 827

We'll have on display not only the complete P-M line, but other, still newer Hannifin control valves... if you cannot attend, be sure to write for

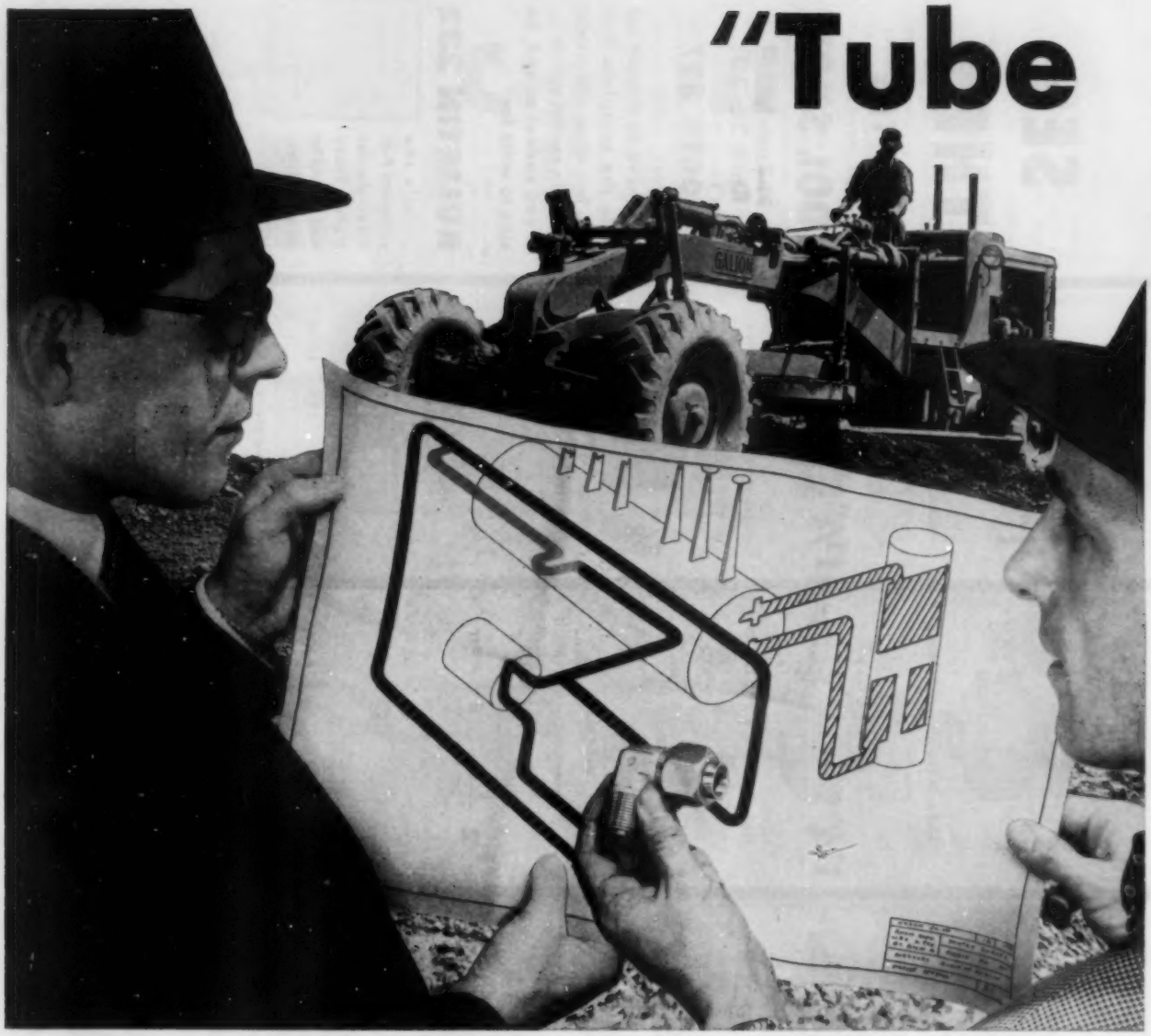
BULLETIN 232

...it's the complete P-M Pilot-Master Valve Story and should be in your files.

HANNIFIN

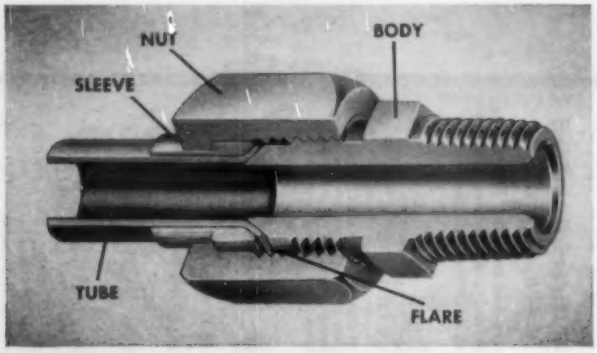
Hannifin Corporation, 1125 S. Kilbourn Ave., Chicago 24, Ill. • Air and Hydraulic Cylinders • Pneumatic and Hydraulic Presses • Riveters • Air Control Valves

"Tube



Design engineers at the Galion Iron Works and Manufacturing Co. of Galion, Ohio, developed a simple, foolproof hydraulic control system for their line of motor graders. It offers a high degree of accuracy, safety, and dependability and has proved to be an outstanding success. One reason: Galion engineers specified Parker *Triple-lok* fittings for every grader they build.

At tube-bursting pressures Parker *Triple-lok* fittings remain intact with absolutely no leakage or distortion. They also hold leakproof over ranges of extremely hot and cold temperatures.



3-piece *Triple-lok* fittings are stocked by distributors in steel, stainless steel, brass and aluminum alloy. They are also available in other materials on special order.

up and forget it"

Use leakproof Parker *Triple-lok* fittings for trouble-free equipment

This motor grader, like most mobile equipment, takes severe punishment during its daily work. Jars and jolts; stresses and strains! Hydraulic control systems must be extra safe and dependable. That's why more and more manufacturers of lift trucks, agricultural and earth-moving machinery are specifying leakproof Parker *Triple-lok* fittings.

These flare fittings are absolutely leakproof even under the severest conditions of vibration, shock, and hot and cold temperatures. Thousands of destruction tests prove they will hold pressures that burst the tubing.

Using *Triple-lok* fittings is the easiest and best way to tube up your equipment. You get low assembly torque, easy disconnection, and repeated reassembly for trouble-free joints.

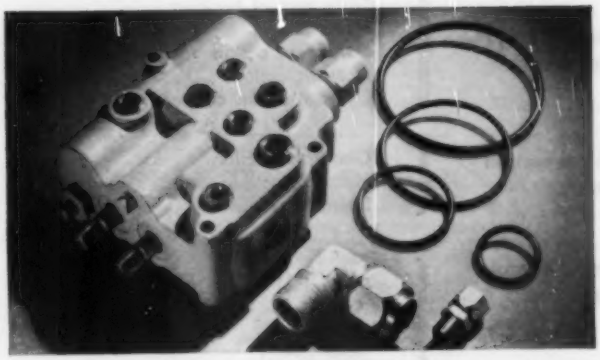
These fittings meet J.I.C. and S.A.E. standards plus specifications of the A.S.M.E. Code for Pressure Piping.

As a matter of fact, *Triple-lok* is the standard of industry. More *Triple-lok* fittings are used on industrial machinery than any other fitting.

So, tube up and forget it. Specify *Triple-lok* fittings for the equipment you build. Parker offers the widest range of shapes and sizes available . . . for tubing outside diameters from ⅛ through 2 inches. Mail the coupon for complete fitting data.

TUBE AND HOSE FITTINGS DIVISION
The Parker Appliance Company
17325 Euclid Avenue, Cleveland 12, Ohio

Parker
Hydraulic and fluid system components



What other Parker products for hydraulic and fluid systems interest you? Ferulok flareless fittings? New hydraulic control valves? Synthetic rubber O-rings?

TUBE AND HOSE FITTINGS DIVISION
The Parker Appliance Company
Section 403-L
17325 Euclid Avenue
Cleveland 12, Ohio

☐ Please send Parker fittings catalog No. 430
☐ Please send descriptive literature about . . .

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COMPANY _____
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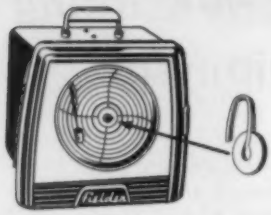
Mail this coupon for catalog of complete information about Parker tube fittings . . . the standard of industry. If you'd like to know about other Parker products, please list them on the coupon.

News About Created-Metals

Thermistors Stabilize Circuit Resistance



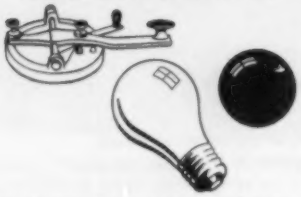
A Carboloy Thermistor improves the accuracy and sensitivity of the Tektolog Electronic Recorder.

Matching the negative temperature coefficient of a Thermistor and a low-resistance manganin shunt to the positive temperature coefficient of the copper coil results in a circuit of constant resistance within ± 5% for ambient temperature from 32° F. to 150° F.

The high degree of compensation is achieved with a relatively low resistance and makes possible accurate recording of voltages as low as 20 millivolts full-scale.

For more information on Thermistors for temperature compensation and detection, warning devices and controls, write: Carboloy Department of General Electric Company, 11127 E. 8 Mile Street, Detroit 32, Michigan.

Many Uses Found for Cemented Carbides

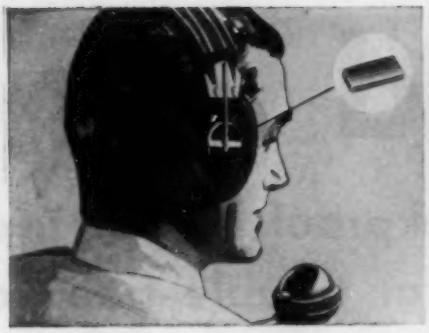


The electronics and electrical industries are cutting costs and improving products with wear-resistant cemented carbides.

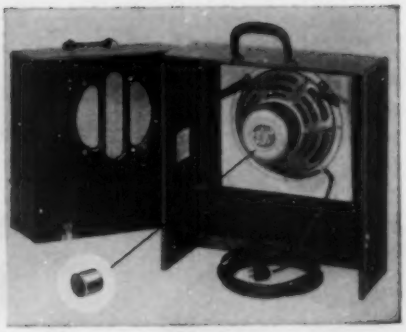
For example, tough grades of Carboloy cemented carbide are extending the life expectancy of telegraph relay contacts. Carbide-tipped tools are saving time and money in woodworking and cabinetry.

Carbide wire dies for making electric-light filaments and draw dies for making component parts far outlast steel dies. Bearings of chrome carbide are light, strong, nonmagnetic.

Industry is daily finding new uses for cemented carbides. The Carboloy Engineering Appraisal Service will help you put carbides to work in your plant. For more information, write: Carboloy Department of General Electric Company, 11127 E. 8 Mile Street, Detroit 32, Michigan.



Small size, light weight and permanent power are essential in military headsets. Carboloy Alnico 2 permanent magnets permit a thinner, lighter receiver with high output and level response.



Public-address loudspeakers utilize the acoustic action of powerful Carboloy permanent magnets. The uniformity and strength of these magnets help produce truer tone.

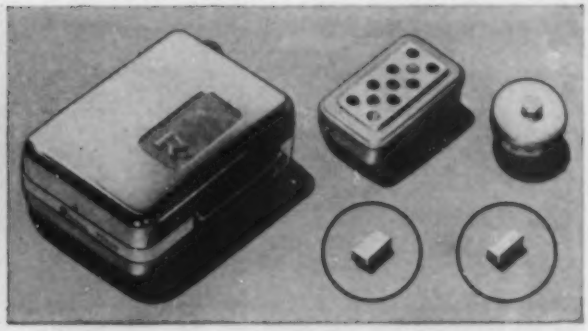
Permanent Magnets

Two Carboloy cast Alnico 6 permanent magnets cut manufacturing costs in this new telephone built by Connecticut Telephone & Electric, Meriden, Conn. One magnet provides acoustic action for receiver; other magnet supplies generator action to operate bell ringer. The magnets' consistent field holds post-assembly adjustment to a minimum.

Basic functions of permanent magnets

1 Convert electrical energy to mechanical motion	Eddy current braking Motor action Instrument action Acoustic action Electron beam control
2 Convert mechanical motion to electrical energy	Generator action Magneto action Sound pick-up
3 Convert mechanical energy to thermal energy	Control of torque
4 Mechanical holding	Snap action Separation Holding and lifting

The heart of this Gibson electric guitar is the magnetic pick-up. Steel strings vibrate in the field set up by two small Carboloy permanent magnets, generating minute electrical impulses.



New all-magnetic, all-transistor hearing aid uses permanent magnets in both microphone and receiver. These tiny magnets eliminate hearing-aid failure caused by operational heat, and by humidity.

improve sound pick-up and acoustic action

They make possible simplified design, lower costs, and improved performance in communication devices and in many other important fields

Carboloy® Alnico permanent magnets are replacing electro-magnets in both the input and output elements of communication devices.

Because permanent magnets convert mechanical motion to electrical energy, they improve sound pick-up action for microphones and other transducers. And because they convert electrical energy back into mechanical motion, they provide the acoustic action necessary in telephone receivers and loudspeakers.

Carboloy permanent magnets supply a uniform source of stable, low-cost energy. By using power-packed permanent magnets, you'll eliminate coils, wires and other operating parts. Design is simplified; product size and manufacturing costs reduced.

Carboloy permanent magnets are available sintered, as well as cast. Sintered magnets hold closer tolerances, permit more complex shapes.

Perhaps Carboloy permanent magnets can improve your products or equipment. Specially trained engineers of the Carboloy Engineering Appraisal Service will work with you on permanent magnet design and application. Send coupon, today, for catalog or design manual.

"Carboloy" is the trademark for products of the Carboloy Department of General Electric Company

CARBOLOY
DEPARTMENT OF GENERAL ELECTRIC COMPANY
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Send me the following without cost or obligation:

☐ Permanent Magnet Design Manual, PM-101
☐ Permanent Magnet Standard Stock Catalog, PM-100

Name _____ Position _____
Company _____
Address _____
City _____ Zone ____ State _____

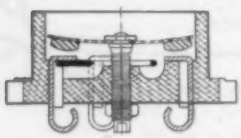
Here's how KLIXON PROTECTORS

Safeguard Motors . . . Cut Costs by Keeping Equipment Running

Because Klixon Motor Protectors are matched and built into the motors by the motor builder, they give you a tested and proven combination that assures full motor life.

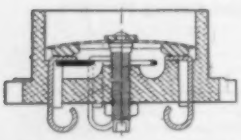
The Klixon Protector provides accurate motor overheat protection. It prevents motors from becoming dangerously hot and burning out . . . yet always permits the motor to operate at maximum capacity.

Here's how they operate —



CLICK! . . . IT'S OFF!

Should a motor become overheated and dangerously hot, the Klixon Protector snaps the power "off" preventing the motor from burning out.



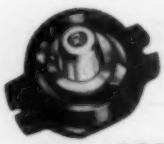
CLICK! . . . IT'S ON!

When the motor cools to safety, the Klixon Protector snaps the power "on" automatically; or when the red button is pushed if the manual reset type is used.

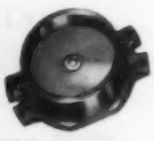
Regardless of the motor driven products that you make . . . from oil burners to machine tools . . . it will pay you to specify and insist that your motor manufacturer supplies you with motors protected with Klixon Protectors. The additional cost is low . . . pays for itself many times over by keeping equipment operating minimizing motor repairs and replacements.

Here's What a Leading Motor Repair Shop Has to Say About Klixon Protected Motors

"We have seen so many cases where a seized bearing or starting switch failure to close would have caused a motor burnout but it was prevented by a Klixon motor protector. We feel Klixon Protectors are definitely a big advantage."



KLIXON



Manual Reset

Automatic Reset

SPENCER THERMOSTAT

Division of Metals & Controls Corporation

904 FOREST ST., ATTLEBORO, MASS.

Now!

K11 ELECTRICAL CONTACTS (RIVETS)

K12 ELECTRICAL CONTACTS (BUTTONS)

General Plate

Electrical Contact Kits for Laboratory and Development Use

A Wide Assortment of Sizes at Your Fingertips . . . Simplifies Design, Saves Time

These two General Plate Electrical Contact Kits are the answer to your contact requirements for development use.

Kit K11 contains a wide assortment of silver rivet contacts. Kit K12 has representative standard button contacts . . . silver facing on a base metal backing for projection welding. Also included are metal strips for fabrication of contact parts.

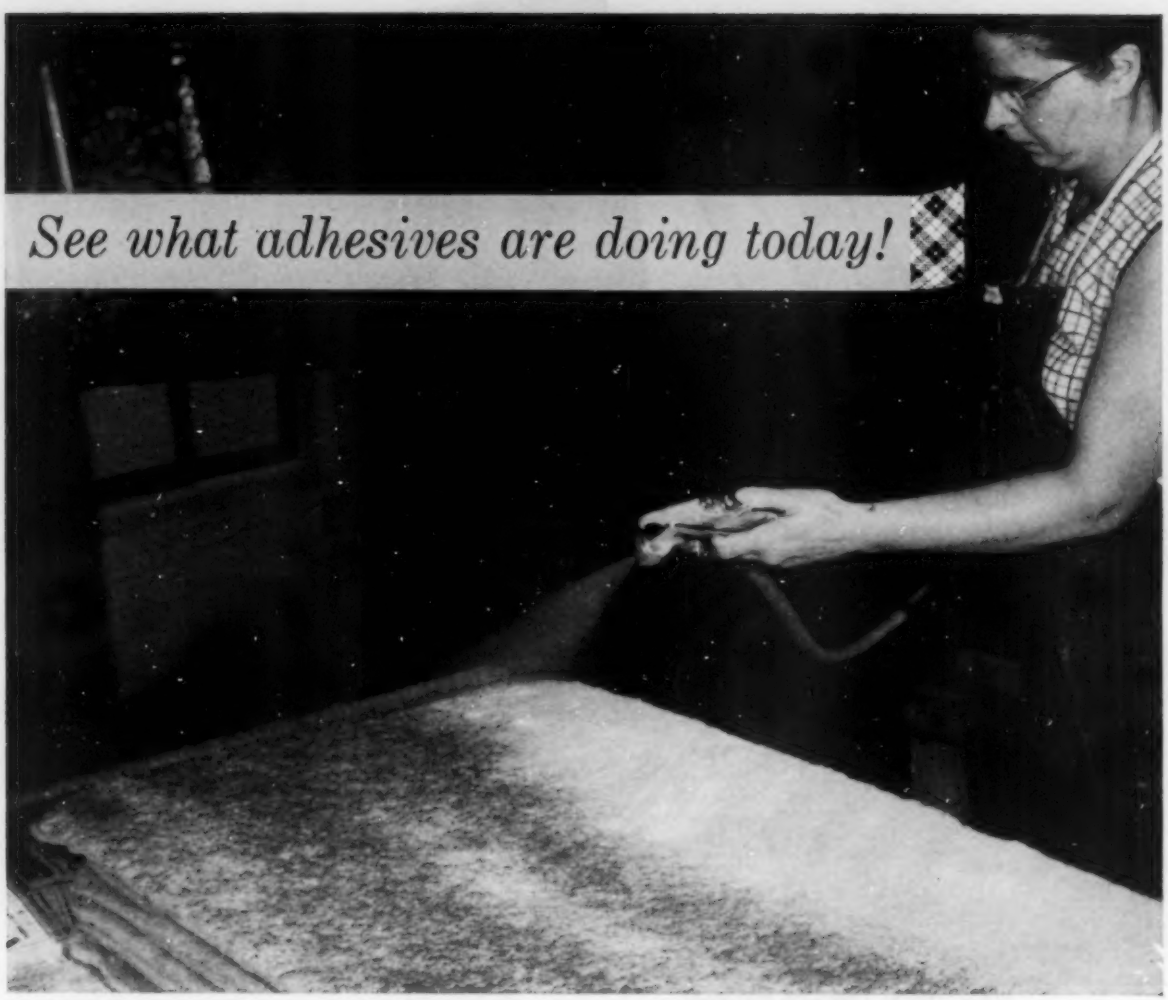
Dimensional working drawings are included so that you can duplicate the exact part on your own drawings.

These General Plate kits help you solve design problems by placing standard stock buttons and rivets at your fingertips. Once a design goes to production, there are no procurement delays . . . production quantities are available for immediate shipment from General Plate stock. Your contact inventories are minimized, "non-standards" are eliminated, delivery delays are avoided.

Available at a nominal cost . . . write for complete information and prices today.

You can profit by using General Plate Composite Metals!

METALS & CONTROLS CORPORATION
GENERAL PLATE DIVISION
14 FOREST STREET, ATTLEBORO, MASS.



Helping to keep firewalls cool

3M COMPANY

There's no question about the value of fibrous glass padding for insulating furnace walls. It's fireproof. It's light in weight. Only problem is—to find a fastening method that will attach the fiber pads to steel quickly and effectively.

When Bard Manufacturing Co. of Bryan, Ohio, had to answer this question they called in a 3M sales representative for consultation. His recommendation was EC-104—a sprayable adhesive that forms an immediate bond between fiber and steel, permitting fast and effective application. Most important, the use of 3M adhesive, EC-104, has permitted this manufacturer of furnaces to insulate cabinets at a much lower cost than any method previously used!

See what adhesives can do for you . . . If your problem is fastening, why not follow Bard's example? Call in your 3M adhesives specialist. He'll be glad to assist you. For more detailed data, write in today for new, informative designer's handbook. For a copy, address your request to 3M, Dept. 44, 417 Piquette Ave., Detroit 2, Michigan.

see our catalog in PRODUCT DESIGN FILE or write for copy

ADHESIVES AND COATINGS DIVISION **MINNESOTA MINING AND MANUFACTURING COMPANY**

417 PIQUETTE AVE. DETROIT 2, MICH. • GENERAL SALES OFFICES: ST. PAUL 6, MINN. • EXPORT: 122 E. 42 ST., N. Y. 17, N. Y. • CANADA: LONDON, ONT.

MAKERS OF "SCOTCH" BRAND PRESSURE-SENSITIVE ADHESIVE TAPES • "SCOTCH" BRAND SOUND-RECORDING TAPE • "SCOTCHLITE" BRAND REFLECTIVE SHEETINGS • "3M" ABRASIVE PAPER AND CLOTH • "3M" ADHESIVES AND COATINGS • "3M" ROOFING GRANULES • "3M" CHEMICALS

Design facts you should know about ALCOA® Aluminum Forgings

Improved equipment and production techniques mean aluminum forgings now compete with other metals and fabricating processes

In the period between 1946 and 1949, production of aluminum forgings increased over 100 per cent at Alcoa alone. With the addition of the large 15,000-ton hydraulic press in the Cleveland Works, along with other equipment since put into operation, production has increased still further. These improved facilities mean higher output of better quality aluminum forgings at a cost that makes them competitive with other metals and other fabricating processes.

What about the future? We suspect you have already heard of the giant 35,000 and 50,000-ton presses now being constructed for our Cleveland Works—expected to be in operation this year—and are aware of the tremendous new design possibilities facilities such as these will provide.

Parts will be still bigger, will have thinner web sections, less draft, closer tolerances, better dimensional stability, to say nothing of being more complicated.

What's more, an ever-increasing share of the aluminum forging output from now on will be commercial, not military. In short, automotive, electrical appliance, tool, and engine designers, in fact, designers in all of industry—taking hints from the military—are turning to aluminum forgings for better, stronger, lighter, yet lower cost parts.

A glance through the next few pages will show you reasons why.

View of 15,000-ton hydraulic forging press operated by Alcoa's Cleveland Works. Not only has this press contributed to research on still heavier presses, it has permitted significant design improvements by way of reducing "small pieces" construction.

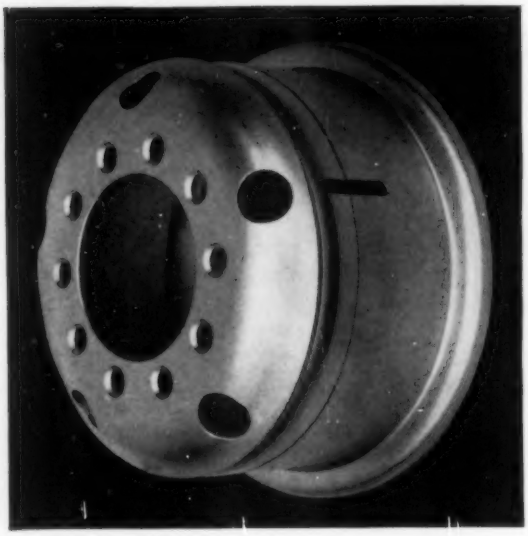
These people use ALCOA Aluminum Forgings

Aluminum forgings possess all the inherent characteristics of aluminum, such as light weight, corrosion resistance, and good machinability; and combine with these advantages great strength, comparable to that of structural steel.

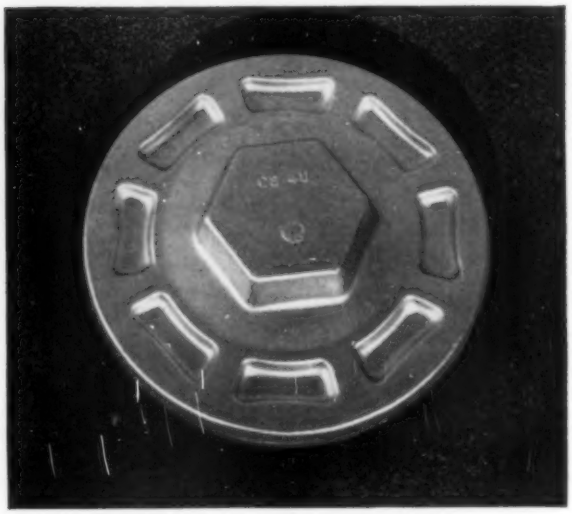
The result: high strength-weight ratios—excellent for such applications as aircraft, truck and bus where range, speed and payload depend on light body weight, yet sufficient strength to support that load.

Weighing about one-third less than structural steel, aluminum forgings help reduce operator fatigue when they are used in parts frequently carried, lifted or handled. Hand power tools are a good example. With their lower elastic modulus, aluminum forgings have several times the impact-absorbing capacity of mild steel.

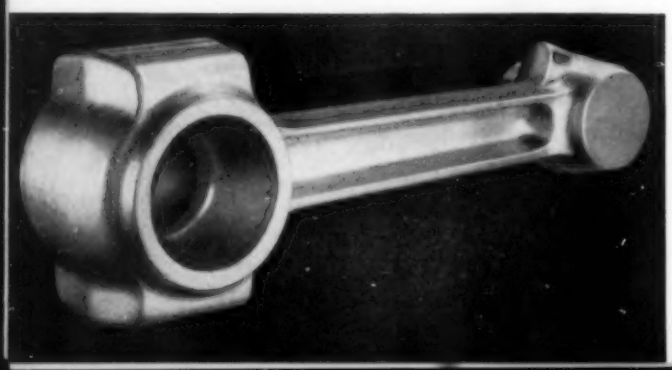
Other features make aluminum forgings stand out. For example, they are easily machined, often at speeds of 1000 fpm. But, their smooth, bright surfaces often make subsequent machining unnecessary. What's more, inspection costs are less. Part dimensions are uniform, keeping scrap loss to a minimum.



FORGED WHEELS—Weighing 48 pounds, 40 less than its steel counterpart, this Alcoa Forged Aluminum Disc Wheel for trucks and buses is proving its superiority by reducing unsprung weight, allowing larger payloads. Machined from an aluminum forging, these wheels literally are rounder which means less vibration, less maintenance.



CUTTER DISK—An Alcoa Forged Cutter Disk to be used on a concrete surfacing machine. Because of their great strength, Alcoa Forgings are perfect for highly stressed moving parts. Further, their light weight means less driving horsepower. Sturdy, these forgings can stand severe abuse in emergencies, provide dependable service under normal load, all with less maintenance.



CONNECTING RODS—Forged aluminum connecting rods not only are strong, but, being light, more of the horsepower developed by the engine can be directed toward driving the outside load rather than the engine's own parts. Alcoa Forged Pistons are in use today in diesel engines driving trucks, buses and railroad locomotives.

Alloy selection

It is possible to produce aluminum forgings with tensile strengths varying between 15,000 and 75,000 psi, depending, of course, on the alloy selected. But you can save money by utilizing that alloy which most nearly matches your strength requirements. Too, each alloy has certain other characteristics that may actually be more significant than strength.

For example, alloy 2S, commercially pure aluminum, has high electrical conductivity and good corrosion resistance; and, because of its shiny appearance, is often used for decorative effects. Or 14S, the general-purpose forging alloy, also has good corrosion resistance coupled with high strength and excellent machinability. Alloy 32S, with its low coefficient of thermal expansion, is highly suitable for diesel engine pistons. Alloy 61S has very good welding and brazing qualities, plus high resistance to corrosion.

But, where very high strength is called for, such as in aircraft or structural installations, alloy 75S is frequently used. Or 76S, with its excellent fatigue strength and high degree of hardness, is perfect for highly stressed parts, such as propellers.

what about cost?

Cost of the piece as it comes from the forging press is only half of the aluminum forging cost story. To keep this half low, Alcoa is constantly adding new equipment and improving the old. For example, the largest facilities in the world for sinking aluminum dies will soon be in operation at the Cleveland Works. And, a new machine for roll forming aluminum rings in sizes up to 40 inches O.D. and 20 inches wide has been added. The ring roller, as it is called, is capable of turning out rings to closer tolerances, with better surface finishes than any previous methods. Then, of course, there's the 15,000-ton press. These new facilities spell more faithful reproduction of design, fewer rejections, faster inspection, hence, lower as-forged costs.

The other half of the cost picture concerns cost per finished piece. As forgings, shapes can be made more complete when they come from the press. The result: design can be greatly simplified, improving quality, and keeping subsequent machining, assembling, and finishing operations to a minimum.

So, if you have hesitated to make your product as an aluminum forging because of cost, take another, longer look . . . today.

New ring roller now in production at Alcoa's Cleveland Works. This machine is capable of producing rings up to 40 inches O.D. and 20 inches wide with closer tolerances, better surface finish, and at lower cost than previous methods.

Want more information?

If you would like to know more about what we at Alcoa have found out about this business of forging aluminum, we'd be glad to send you a cloth-bound book, *Designing for Alcoa Forgings*, that is sure to answer many of your questions.

Write on your company letterhead, telling us your job function, to ALUMINUM COMPANY OF AMERICA, 1992-D Alcoa Building, Pittsburgh 19, Pennsylvania.

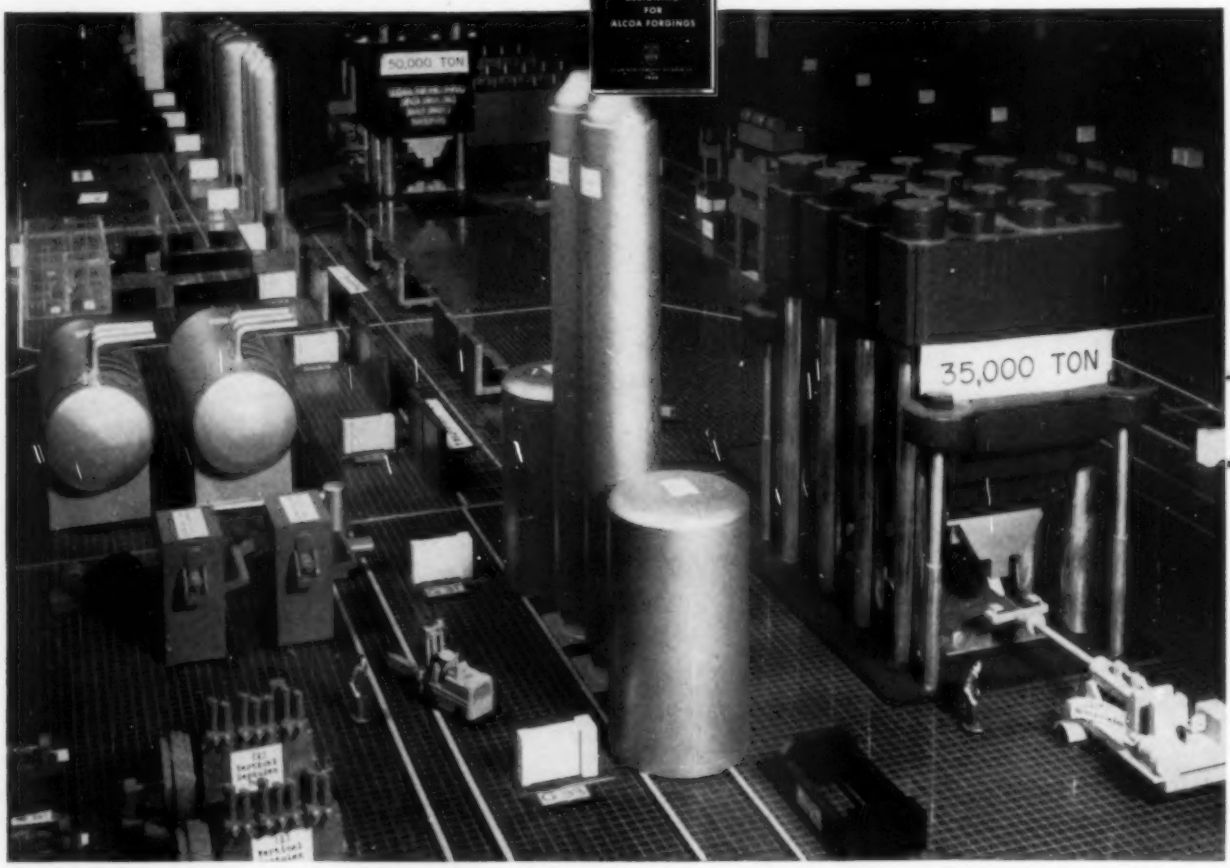
In this book, you'll find detailed facts on why you should keep radii full and fillets generous—why it's important not to blend radii unless it's absolutely essential—how sharp corners can cause the diesinker troubles, possibly lessen die life.

Too, the book goes into great detail on draft angles —for most shapes, 7° is standard, but this can vary downward according to the size and shape of the part as well as the alloy employed. A whole section is devoted to web and rib thickness, their design and relationship to cost. For example, for thin webs, dimensional tolerances are hard to maintain because the web cools more quickly and shrinks faster than other parts of the forging.

It tells how, by taking advantage of metal flow, maximum mechanical properties can be obtained at critically stressed sections. Further, the parting line is discussed in relation to part design, cost and quality.

All these facts and others not mentioned are important to you. Write for your book soon. And, if you have some question you'd like to discuss now, there's an Alcoa sales engineer near you. His office is listed under "Aluminum" in your classified telephone directory. Don't hesitate to call him—to use his time and knowledge freely.

ALCOA ON TV brings the world to your armchair with "SEE IT NOW" featuring Edward R. Murrow, Tuesday evenings on most CBS-TV stations.



Scale models of the 35,000 and 50,000-ton presses expected to be in operation sometime this year. Building that will house the two presses will be more than 100 feet high over the press bay, will cover about 12 acres of land—more area than six full-sized football fields.

HOW DOES YOUR DRAFTING ROOM LOOK AT 5:05 P.M.?

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Many companies, even those with small drafting rooms, save hundreds of drafting hours each week by using modern photocopy techniques. And these dramatic labor savings can be achieved without additional capital investment! Successful photocopy depends on gearing the machines, materials and methods to the company's specific needs. This job calls for expert photocopy counsel . . . a unique service of Peerless factory distributors.

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PEERLESS PHOTO PRODUCTS, INC.

Shoreham, Long Island, N. Y.

Manufacturers of Quality Photocopy Papers and Special-purpose Industrial Photocopy Equipment

Fluid, Fast-Curing Plastisols Make Product Fabrication Easy

This booklet tells how to get better performance, more sales features for your product —*plus* a choice of production techniques — all fast — and all using simple inexpensive equipment.

Plastisols based on BAKELITE Vinyl Dispersion Resins are the answer. They can be used for slush molding, dip-coating — even poured into place. Baking at only 350 deg. F. quickly cures them into a finished, flexible product.

They pick up intricate mold details — give you a choice of soft or glossy surfaces. You control their resiliency by using the required amount of plasticizer. Color them to any tint or shade by mixing pigment dispersions into the uncured fluid.

Tough, resilient plastisols based on BAKELITE Vinyl Dispersion Resins resist moisture, weather, acid and alkali solutions, oil and grease. They withstand abrasion, engine heat, corrosive atmospheres. Their dielectric properties are excellent.

Applications that have proved successful will give you some ideas. Learn about them from the free booklet, "BAKELITE Vinyl Dispersion Resins for Organosols and Plastisols." Write Dept. UT-10.

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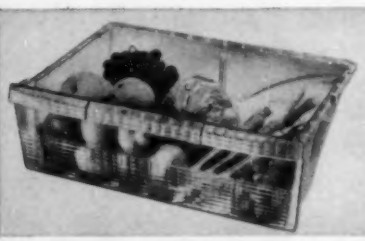
TRADE-MARK
VINYL DISPERSION RESINS

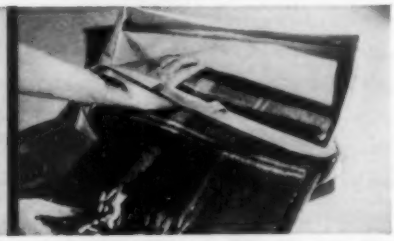
TRADE MARK

BAKELITE COMPANY
A Division of
Union Carbide and Carbon Corporation
UCC
30 East 42nd Street, New York 17, N. Y.

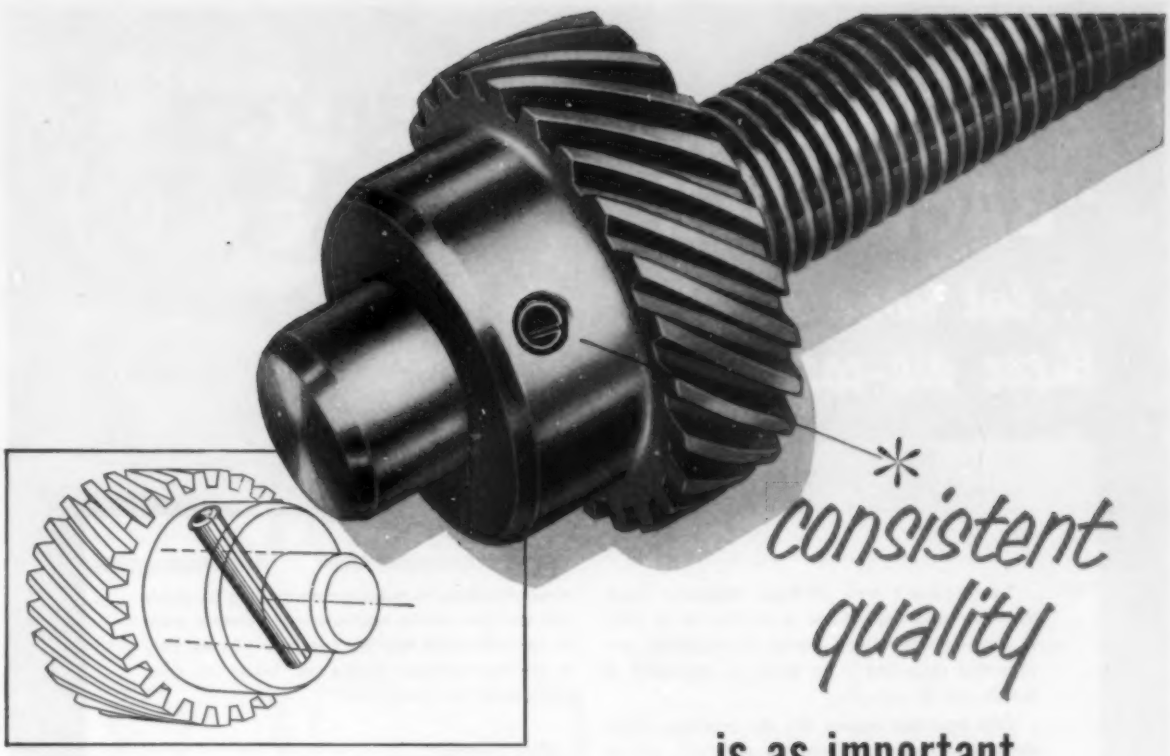
15 YEARS' DUTY . . . and in perfect condition! Extra-heavy traffic (15,000,000 people) in 22-story office building has caused no appreciable wear on this elevator entrance floor tread. It's KenFlex, made of BAKELITE Vinyl Resins by Kentile, Inc., Brooklyn, N. Y.



PRODUCTION SPEEDUP of 13 per cent resulted when BAKELITE Styrene Plastics were used for this refrigerator vegetable crisper. It's molded in one piece, has fine details, transparent blue-green color, weighs only 45 oz. Molded by General Electric Co., Decatur, Ill.



TRANSPARENT WINDOW on this blanket case reveals motor robe's pattern and color, increasing attractiveness of package. BAKELITE Vinyl Rigid Sheet window stays flexible, won't discolor or tear in normal use. Made by William Ayres & Sons, Philadelphia, Pa.



* consistent quality

is as important in the pin as in the gear

To function effectively, a spring pin must drive easily into holes drilled to normal production tolerances, compressing as driven. To drive easily, hold firmly and fit flush, the pin —*every* pin—must meet the strict requirements of specifications such as those prepared by the SAE and the Military Services.

Since failure of a pin can be as costly as a failure of any other precision part, it is important to check the pins *you* buy for uniformity . . . uniformity of diameter and length, shear strength, hardness, insertion and removal forces, and recovery of diameter.

Rollpin has been tested many times—by many manufacturers—with a consistently high performance record. It has been widely recognized as the "quality" fastener of its type. In this case, quality can be—and should be—measured. We strongly urge that you test for quality when buying spring pins.

ELASTIC STOP NUT CORPORATION OF AMERICA

Dept. R28-42, Elastic Stop Nut Corporation of America
2330 Vauxhall Road, Union, New Jersey

Please send the following free fastening information:

☐ Rollpin samples
☐ Rollpin bulletin
☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name_____ Title_____

Firm_____

Street_____

City_____ Zone____ State_____

24 HOURS OF "BACK TALK"

...but none about these die-cast parts

CASE HISTORIES FROM MT. VERNON FILES

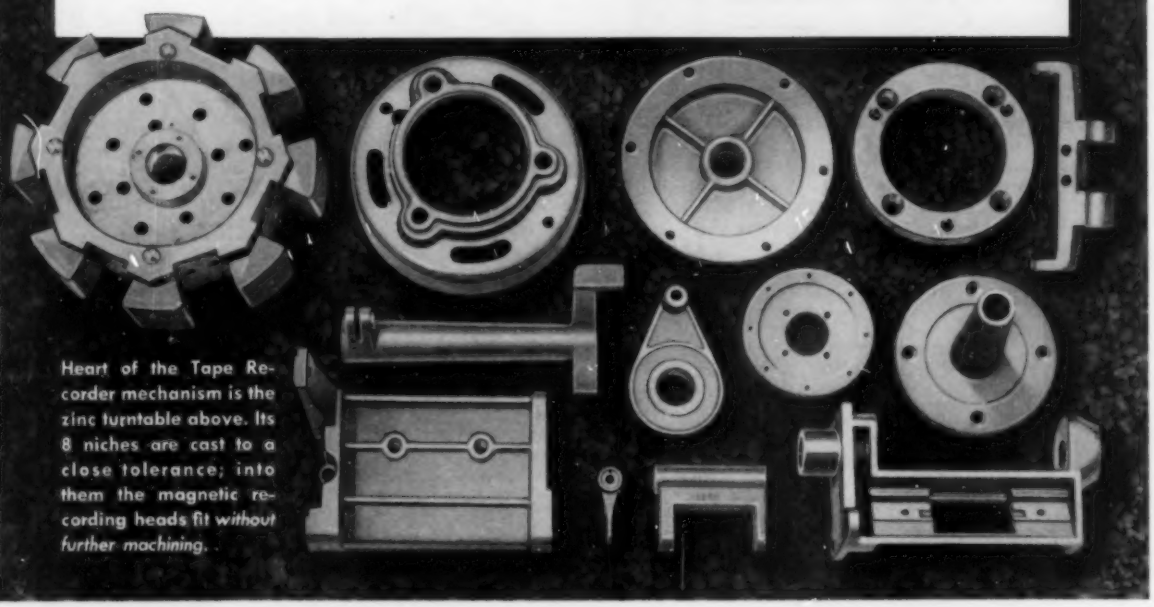
Soundscriber's new 24-hour Magnetic Tape Recorder and Reproducer is the first in its field to provide such a long period of continuous, unattended recording in so small an instrument. It weighs but 80 pounds.

One important reason why this precision instrument is so light, so thoroughly practical, yet so moderate in cost, is the die cast aluminum and zinc parts you see here.

States Soundscriber Corporation: "From long experience with our standard line of dictating equipment, we have found die casting a lower-cost way of making intricate parts. Further, this method allows for more economical use of lightweight metals. Mt. Vernon die casting has always met our high quality standards."

Whatever *your* product, simple or intricate, it will pay you to consult with us. We have up-to-the-minute facilities for precision die casting of aluminum and zinc, and a vast reservoir of experience. It's quite possible that we can show you the way to greatly increased production, lower unit costs —improved products, too.

MT. VERNON
DIE CASTING CORP.
STAMFORD, CONNECTICUT

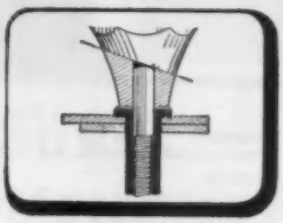


Heart of the Tape Recorder mechanism is the zinc turntable above. Its 8 niches are cast to a close tolerance; into them the magnetic recording heads fit *without further machining.*

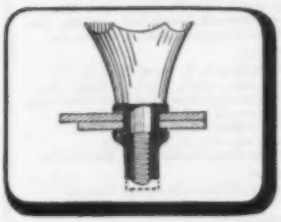
One B. F. Goodrich Rivnut does two fastening jobs, cuts assembly cost!

Rivnuts provide at least 6 clean threads in one simple operation!

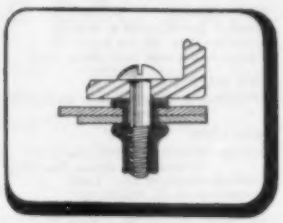
1. Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.



2. Rivnut is inserted—head firmly against work—tool at right angles to work.

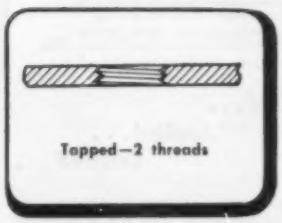


3. Tool lever operates pull-up stud, forming a bulge in the Rivnut shank.

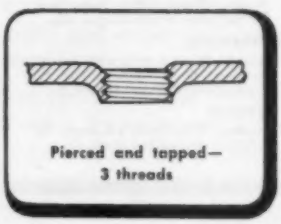


4. After upset, Rivnut threads are still clean and intact, ready for screw attachment.

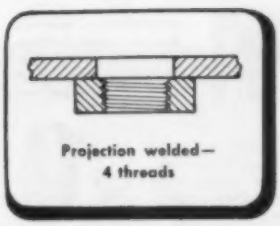
Compare these 4 methods of putting screw threads in thin sheet metal



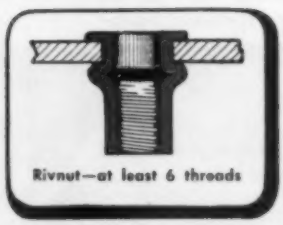
Tapped—2 threads



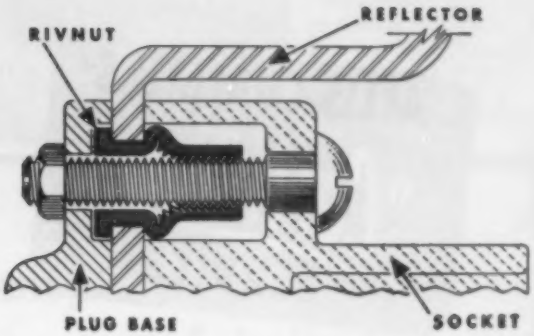
Pierced and tapped—3 threads



Projection welded—4 threads



Rivnut—at least 6 threads



B. F. GOODRICH RIVNUTS cut assembly time and costs since they provide a firm, accurate nut plate in one quick operation. Welding, tapping are eliminated. Rivnuts can be installed from *one side* and can take an attachment bolt from either end.

In the application above (assembling spotlights) Rivnuts completely eliminated use of threaded studs which required welding in close quarters. They also eliminated a separate piercing and tapping operation and made it possible to attach nuts from the outside of the assembly instead of the inside. Rivnuts provided further cost savings since they could be attached *after* enameling without marring the finish of the unit.

Whatever your fastening problem, there's probably a B. F. Goodrich Rivnut that can cut both assembly time and costs. Get complete information and engineering help by calling in a B. F. Goodrich Rivnut engineer. *The B. F. Goodrich Company, Department PE-44, Akron, Ohio.*

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Demonstrates with motion how you can use Rivnuts to fasten TO *and* fasten WITH. Explains construction, gives proved applications . . . Write for your free copy today to The B. F. Goodrich Company, Department PE-44, Akron, Ohio.

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Omaha—Omaha Electrical Works

NEW HAMPSHIRE
Concord—A. S. Tracy

NEW JERSEY
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Paterson—Elec. Service Repair Co.
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NEW MEXICO
Albuquerque—Electric Motor Company
Powell Electric Co.

NEW YORK
Buffalo—Robertson Electric Co.
Volland Elec. Equip. Co., Inc.
Flushing—Flushing Elec. Corp.
Jamestown—A. E. Westburgh
Mt. Vernon—H. A. Schreck, Inc.
New York—Consol. Elec. Motor Co.
Rochester—Vanderlinde Elec. Corp.
Utica—Mather, Evans & Diehl Co.
Watertown—Watertown Elec., Inc.

NORTH CAROLINA
Charlotte—Southern Elec. Service Co.
Greensboro—Southern Elec. Serv. Co.
Rocky Mount—Hammond Elec. Co.

OHIO
Cincinnati—Cincinnati Elec. Equip. Electric Service Co.
Akron—A-C Supply Co.
Toledo—Romanoff Elec. Motor Serv.
Youngstown—Winkle Electric Co.

OKLAHOMA
Miami—Miami Armature Works
Oklahoma City—Southwest Elec. Co.
Tulsa—Smith-Milligan Electric Co.

OREGON
Eugene—Kalen Electric & Mach. Co.
Portland—Milwaukee Mach. Co.

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Johnstown—Universal Elec. Mfg. Co.
Osceola Mills—Mid-State Elec. Eng. Co.
Philadelphia—Elec. App. & Repair Co.
Pittsburgh—Penn. Elec. Coil Corp.
York—Industrial Electric Company

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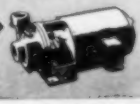

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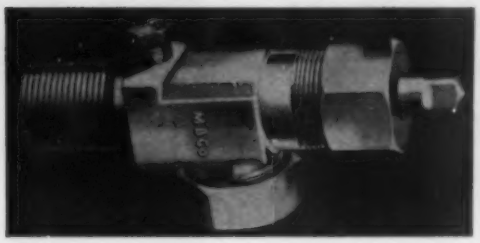
Durable . . . bottle-capping unit uses cast Nickel-Silver. (Courtesy of Universal Castings Corp., Chicago, Ill.)



Corrosion-resisting . . . chlorine gas cylinder valve body of Nickel-Silver. (Courtesy of Mueller Brass Co., Port Huron, Mich.)

Nickel-Silver

A Glamour Metal for Many Uses

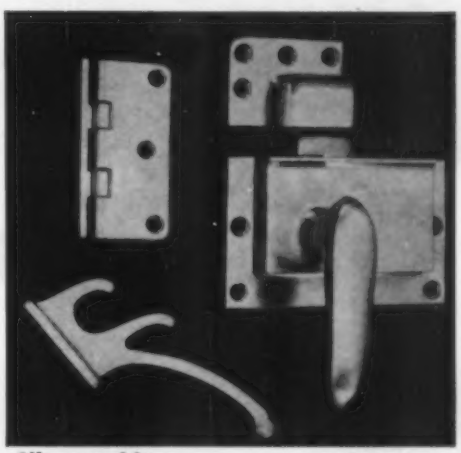
Durable...yet easy to cast or fabricate, machine and polish

Economy and speed of fabrication plus low maintenance cost make Nickel-Silver an excellent material for "appearance" castings whether subject to considerable handling, rubbing and scouring in service, or merely standing idle for decorative purposes...

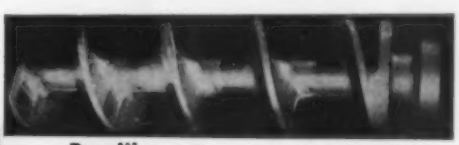
Or . . . wherever you wish the corrosion resistance, or the beauty of lustrous copper-nickel-zinc alloys whose silvery white color lends permanent richness to your product.

Applications include chandeliers, balustrades, ornamental grills, doors, railings and banisters for architectural artistry ...hinges, locks, door handles, dining car hardware, shipboard trim, deck fittings, household plumbing fixtures, laundry machine parts, soda fountain fittings, packaging, bottling and similar machinery, scale and typewriter components and thousands of other articles.

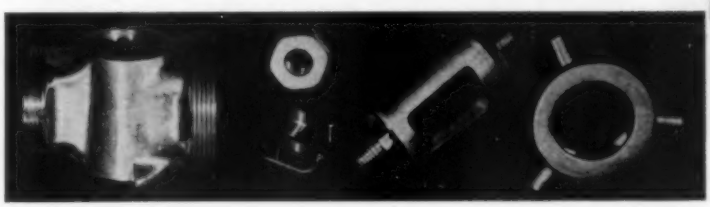
Increase your product acceptance and at the same time improve quality and cut costs...by using one of the standard grades of Nickel-Silver best suited to your needs. Additional information on these versatile alloys is yours for the asking . . . write for a copy of our bulletin, "Nickel-Silver Castings," now.



Silvery white . . . wear-resistant Nickel-Silver fixtures for railway passenger cars. (Courtesy of Loeffelholz Co., Milwaukee, Wisc.)

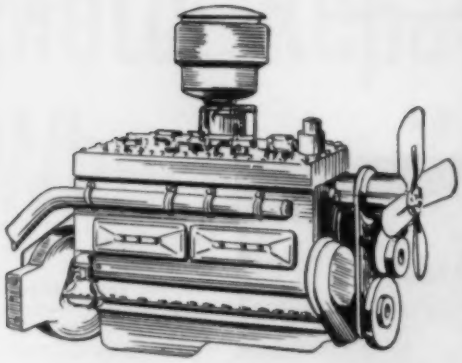


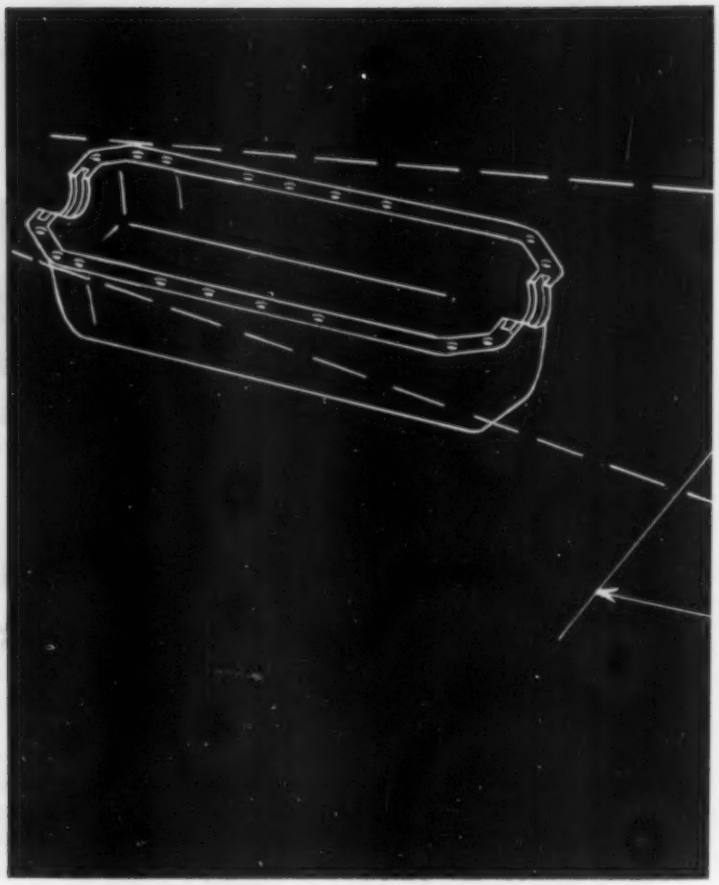
Readily cast . . . packaging machinery components of Nickel-Silver. (Courtesy of Arthur Harris & Co., Chicago, Ill.)



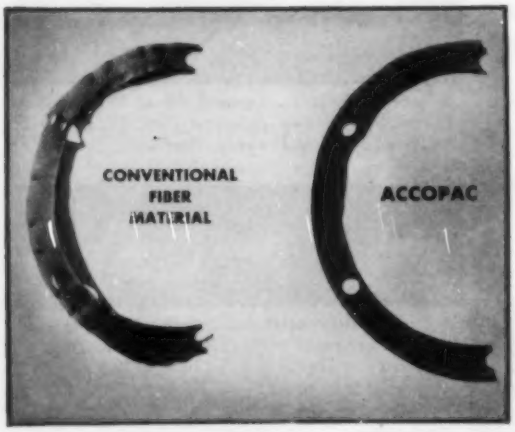
Versatile . . . Nickel-Silver used in cast valve for meat-packing machine. (Courtesy of Lakeside Bronze, Inc., Buffalo, N. Y.)

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.





New fiber gasket stops leaks at oil



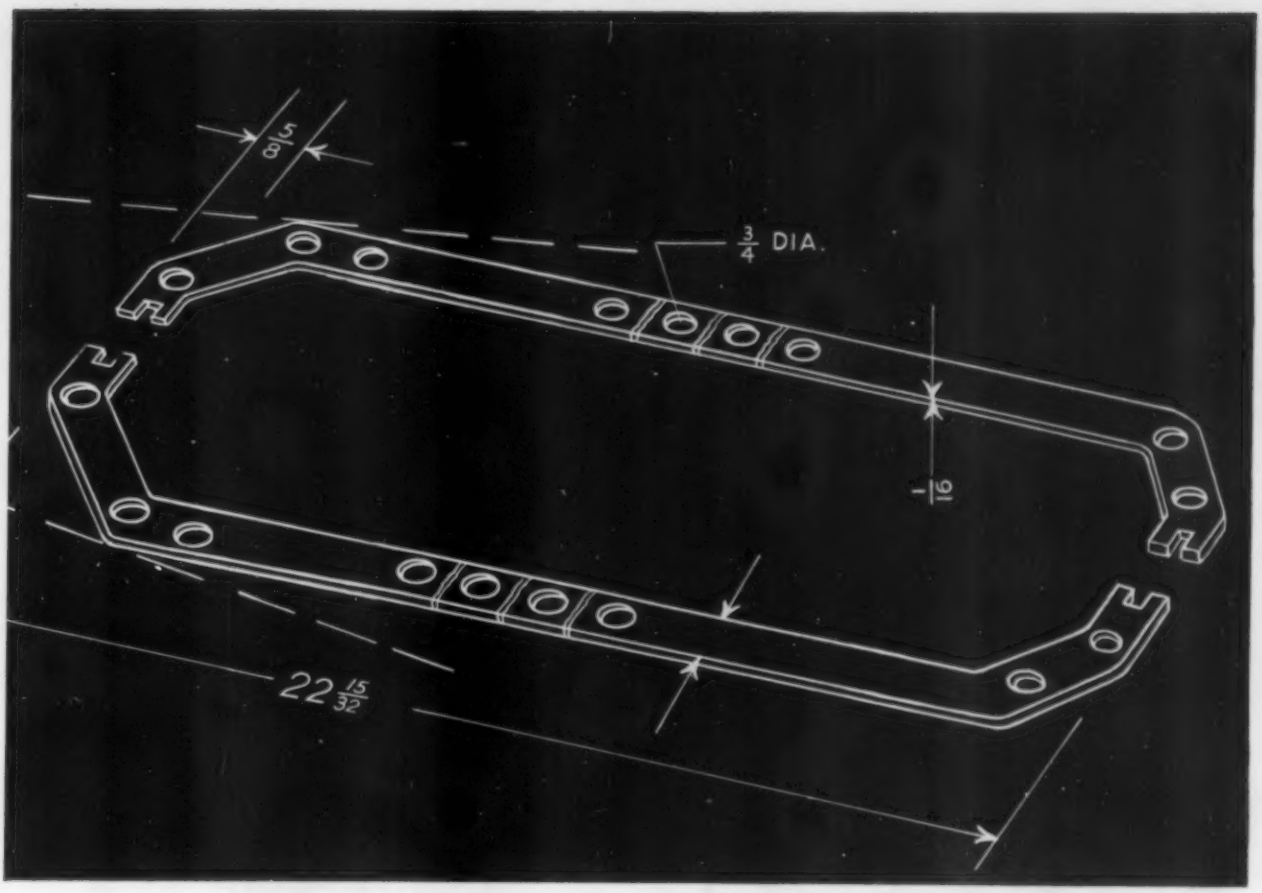
WON'T SHRINK OR DRY OUT. Both these gaskets were used for six months in a gear pump circulating hot hydraulic oil. The plant fiber gasket (left) lost its glycerine plasticizers, dried out, shrank, became hard, brittle. The Accopac gasket (right) remained virtually unaffected, as the photograph clearly shows.

When two sealing materials are used in one application, you have to be certain they will work together effectively. For example, field tests showed that this automotive manufacturer had an unusual sealing problem. The twin gaskets between oil pan and engine block were so compressible that normal bolt torque of 30 to 40 ft-lb caused the rubber seal between oil pan and bearing cap to deform sufficiently that leakage occurred.

One of the suggested solutions for this problem was an entirely new gasket material, Armstrong's Accopac®. This new fiber gasketing had the right combination of compressibility and imperviousness to seal the pan without causing leakage at the bearing cap. After 60,000 miles of road tests, it was established beyond doubt that Accopac CS-301 would effectively prevent leaking and seepage. Since Accopac was less expensive than other gasket materials tested, it was the natural choice for the job.

Compressibility to suit any need—Finely ground cork particles added to Accopac's fiber and latex composition give it a high degree of compressibility. By varying the amounts of

ARMSTRONG'S



pan shaft seal, cuts costs

cork and rubber, Accopac can be compounded for a wide range of applications. Accopac gaskets work well on light, stamped flanges—and equally well on rough, heavy joints.

Won't dry out or shrink—A new, patented beater saturation process covers each fiber in Accopac with a coating of latex *before* the sheet is formed. This locks the fibers in rubber, makes Accopac impervious and dimensionally stable over long periods of storage. Not even hot oil will cause Accopac to shrink, dry out, or leak when used in any recommended application.

FREE 24-PAGE GASKET MANUAL

For full information on Accopac and other versatile gasket materials, write for the 24-page manual, "Armstrong's Gasket Materials." Contains latest information on specifications, plus data on cost reduction, gasket tolerances, flange and joint design, etc. See it in Sweet's Product Design File or write Armstrong Cork Company, Industrial Div., 7004 Irvin Street, Lancaster, Penna.

HIGH RUBBER CONTENT. This microphotograph (100X) shows how completely and uniformly each fiber and each cork particle are enclosed with latex. Accopac is tight, uniform, homogeneous. Strength is very nearly equal either with or across machine direction of a fiber sheet made by this patented process.

ACCOPAC

U. S. Rubber Parts Help Caterpillar-built Machines Move the Earth

This is the rugged, new 66 DBHP Caterpillar No. 6 Shovel capable of handling 2 cubic yards of any material from rock to snow. U. S. Rubber products play an important part in its performance.

Millions of cubic yards of materials are moved by powerful, modern Caterpillar® machines. These husky units have gained fame throughout the world for outstanding dependability and performance. United States Rubber Company products have helped make this performance possible.

Working closely with Caterpillar Tractor Co. engineers, United States Rubber Company is producing rubber parts for these rugged earth movers, including seals, rings, hose, and other products that can absorb the hard shocks that go with the tough job of earth moving.

Manufacturers of a wide variety of industrial products have found the answer to many problems in "U. S." engineering service. They want their products to last longer, perform better—and they know "U. S." has the experience and research facilities to help them out. You, too, can find an answer at "U. S." Call on any of our 25 District Sales Offices, each staffed with sales engineers, or write to address below.

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Hose • Belting • Expansion Joints • Rubber-to-metal Products • Oil Field Specialties • Plastic Pipe and Fittings • Grinding Wheels • Packings • Tapes Molded and Extruded Rubber and Plastic Products • Protective Linings and Coatings • Conductive Rubber • Adhesives • Roll Coverings • Mats and Matting

Look what *You* can do with Alcoa Aluminum on your Acme-Gridley automatics

Free-machining Alcoa® Aluminum Screw Stock and your Acme-Gridley automatics form smooth-working, fast-working teams. They can knock out aluminum parts easily, cheaply and fast. With aluminum, you can take full advantage of Acme-Gridleys' direct, close-coupled camming and wide-open tooling zone features to thread, tap, ream or deep drill. High speeds and feeds are possible with good surface finishes and close tolerances, uniformly maintained.

Piece costs are much lower since you can get three times as many parts from a pound of aluminum as from a pound of heavier metals. In addition, they are excellent conductors of electricity and heat. Aluminum parts take all finishes and are highly resistant to corrosion.

Find out for yourself what *you* can do with Alcoa Aluminum Screw Machine Stock. Contact your local Alcoa distributor or Alcoa sales engineer—your sources for Alcoa Aluminum and your short cut to experience in machining aluminum. Their offices are listed under "Aluminum" in the classified section of your telephone directory. Or, write ALUMINUM COMPANY OF AMERICA, 853-D Alcoa Bldg., Pittsburgh 19, Pa.

Alcoa offers *Alcoa Aluminum in Automatic Screw Machines*, a 95-page book containing information on tool design, setup and operating techniques. It is available to you at no cost just by writing on your company letterhead telling us your job function.

ALCOA ON TV brings the world to your armchair with "SEE IT NOW" featuring Edward R. Murrow, Tuesday evenings on most CBS-TV stations.

ALCOA ALUMINUM

ALUMINUM COMPANY OF AMERICA

FOOTE BROS. LINE-O-POWER DRIVE
Equipped with famous Duti-Rated Lifetime Gears for more power in less space!

Greater Capacity

COMES IN A SMALLER PACKAGE

FOOTE BROS. Duti-Rated LIFETIME GEARING

FOOTE BROS.

Better Power Transmission Through Better Gears

Manufacturers of industrial gears and enclosed gear drives of all kinds, gear motors, aircraft-quality gears and actuators and special machinery

WITH FOOTE BROS.

Duti-Rated LIFETIME GEARING

A unique development in industrial gear production . . . new, *Duti-Rated Lifetime Gears* . . . a Foote Bros. exclusive! From its vast experience as a leader in aircraft-quality gear manufacture, Foote Bros. has applied the important characteristics of aircraft gearing to its *industrial* gear production. The results are highest quality gears with greatly reduced mass, longer life and higher capacity than ordinary industrial gears. What's more, Duti-Rated Lifetime Gears can *actually cost less* than other gears of similar capacity! The time to investigate is *now* . . . the gears to specify are *Duti-Rated Lifetime Gears!*

WRITE FOR COMPLETE DETAILS . . . on how Foote Bros. Duti-Rated Gears can fit into your picture. Write *today* . . . for better power transmission *tomorrow!*

FOOTE BROS. GEAR AND MACHINE CORPORATION • 4545 SOUTH WESTERN BOULEVARD • DEPT. W • CHICAGO 9, ILLINOIS

Users praise Phillips Cross-Recessed-Head Screws

BUCHANAN'S pres-*SURE*-tool is here assembled with Phillips screws by Harold Kennedy. "We simply cannot afford to have our products 'gummed up' by unsightly burrs and mutilated heads," says Albert Mittleman, Plant Superintendent and Production Manager. "It was this feature more than any other which so completely sold us on Phillips screws that we will continue to use them in all new products wherever design permits."

YANKEE METAL PRODUCTS' SEALED BEAM FOGLIGHTS are fastened with Phillips SEMS. "Increased production was immediately evident," says L. Fleischman, production manager, "in that the self-centering feature of the Phillips head made possible the application of power screw drivers. The high percentage of misses and rejects was eliminated. We have been using Phillips head screws since 1936 and we would most definitely not use any other type."

THE HIGH ENAMEL FINISH OF TITAN'S THERM-O-DIAL HEATERS is in no danger of costly damage when Phillips screws are used. "With ordinary screws," Richard K. Fleischman, Titan vice-president, points out, "driver slippage and insecure gripping of the driver bit enforced additional hardships on the driver tools themselves. Drivers last indefinitely with Phillips screws."

MANUFACTURERS OF PHILLIPS CROSS-RECESSED-HEAD SCREWS

THE FASTENERS OF TODAY... AND OF THE FUTURE

X marks the spot

... the mark of extra quality

American Screw Company • Atlantic Screw Works, Inc. • The Blake & Johnson Co. • Central Screw Company • Continental Screw Company • The Eagle Lock Company Elco Tool and Screw Corporation • Great Lakes Screw Corporation • The H. M. Harper Co. • The Lamson & Sessions Company • National Lock Company • The National Screw & Manufacturing Co. • Parker-Kalon Div. General American Transportation Corporation • Pheoll Manufacturing Co. • Rockford Screw Products Co. • Scovill Manufacturing Co. • Shakeproof • The Southington Hdwe. Mfg. Company • Sterling Bolt Company • Wales-Beech Corp.

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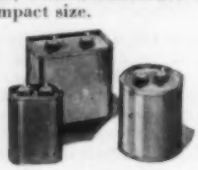
Specify...

MALLORY PLASTIC CASE AC MOTOR CAPACITORS

For Your Motor Running Capacitors . . . Specify Mallory for Dependability

They are available in round, oval and rectangular shapes to meet your requirements.

They are impregnated with Mallotrol A*—a synthetic, non-inflammable oil which permits compact size.



They are available with or without mounting hardware.

All popular capacitance and voltage ratings to choose from.

*Trade Mark

- ***Complete humidity protection.*** Mallory pioneered the plastic case that gives you positive protection against humidity.
- ***Absolute uniformity.*** You can be sure all Mallory Motor Capacitors have identical electrical characteristics . . . and that they will remain stable during a long service life.
- ***Outstanding durability.*** You can count on Mallory performance under the most difficult conditions. They give outstanding service in high temperatures . . . better heat dissipation...longer life, on the shelf and in service.
- ***Easy, fast mounting.*** Mallory Capacitors are designed for economical production line mounting . . . on or off the motor.

When you buy Mallory, you buy the best. For literature and complete information, write or call us today.

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Metallurgical—Contacts • Special Metals and Ceramics • Welding Materials

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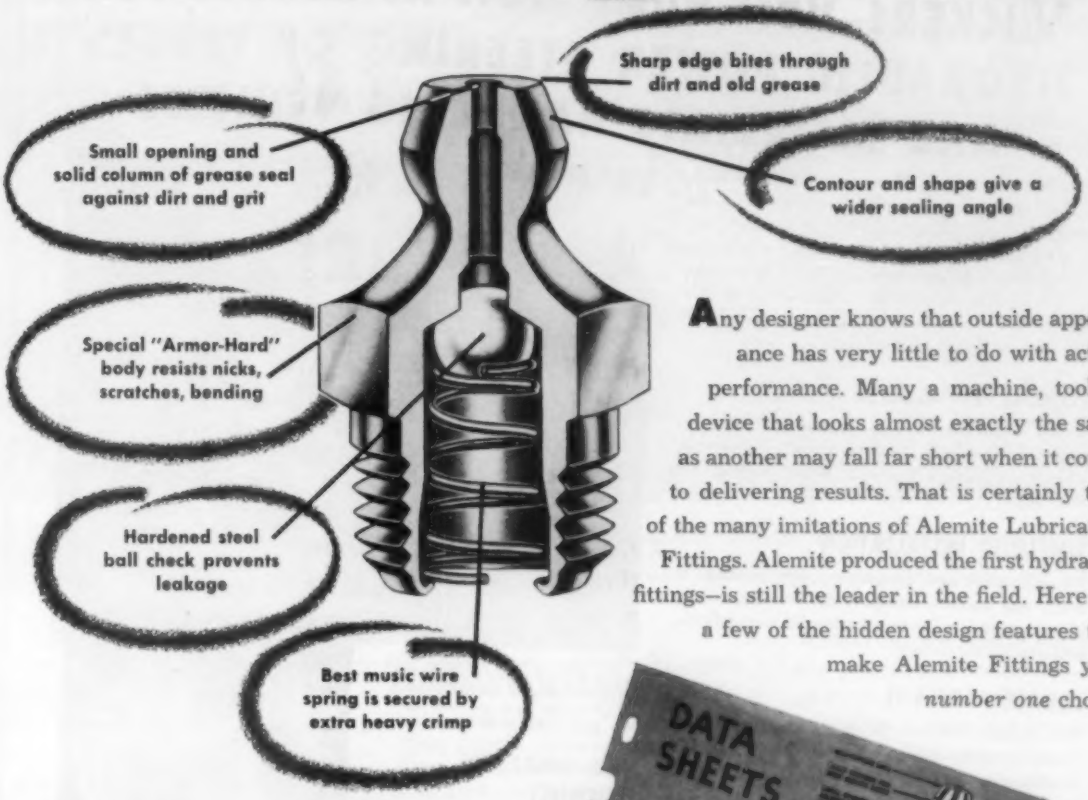
MALLORY
P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

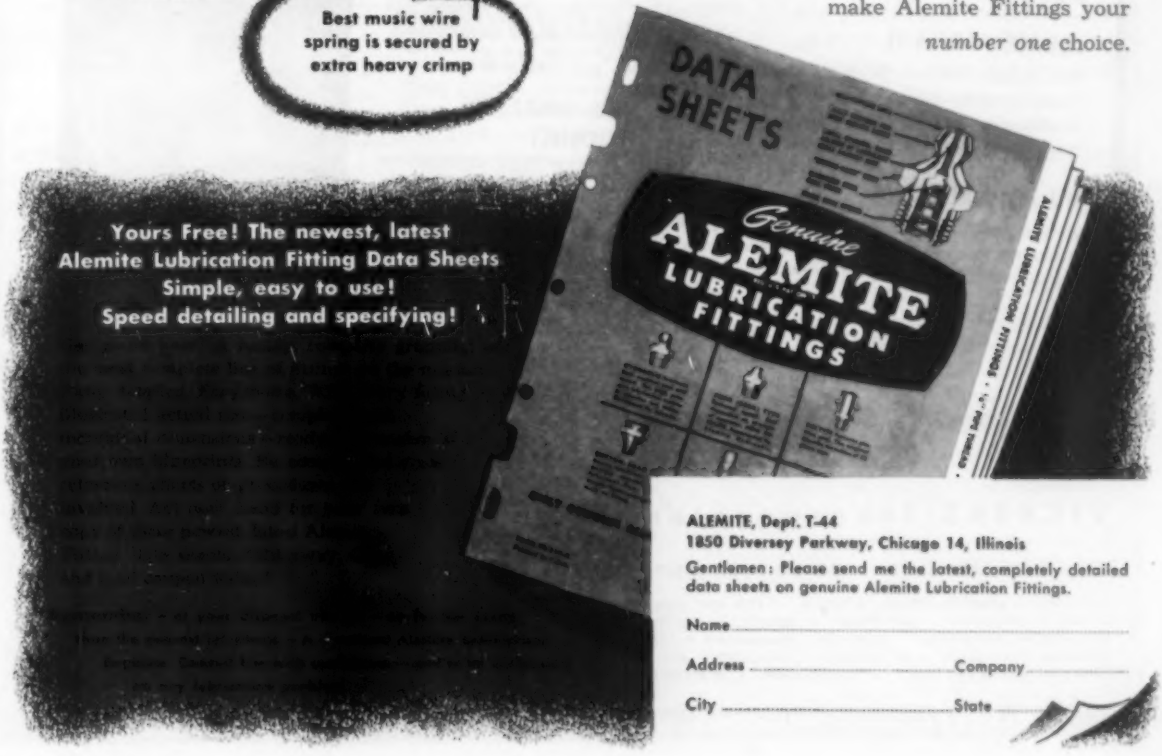
Important design features inside the fitting make the difference!

Genuine Alemite Fittings

your number one choice for any lubrication application!


Sharp edge bites through dirt and old grease
Small opening and solid column of grease seal against dirt and grit
Contour and shape give a wider sealing angle
Special "Armor-Hard" body resists nicks, scratches, bending
Hardened steel ball check prevents leakage
Best music wire spring is secured by extra heavy crimp

Any designer knows that outside appearance has very little to do with actual performance. Many a machine, tool or device that looks almost exactly the same as another may fall far short when it comes to delivering results. That is certainly true of the many imitations of Alemite Lubrication Fittings. Alemite produced the first hydraulic fittings—is still the leader in the field. Here are a few of the hidden design features that make Alemite Fittings your *number one* choice.



HYDRAULICS FOR MOBILE EQUIPMENT

VOL. 2

Mobile Equipment News

VICKERS INCORPORATED, DETROIT, MICHIGAN

IMPROVES PERFORMANCE • CUTS COSTS

NO. 4

VICKERS® VT16 PUMP NOW AVAILABLE FOR HYDRAULIC POWER STEERING OF TRUCKS AND MATERIALS HANDLING VEHICLES

The Vickers Series VT16 pump is used more widely than all other makes combined for the power steering of automobiles. It is now available for the first time for the hydraulic power steering of trucks and materials handling vehicles. It has all the characteristics important to this service and is used in a separate hydraulic circuit for steering only.

COMPLETE PACKAGE

Series VT16 has integral volume control valve and relief valve . . . also an integral oil reservoir. This is a complete hydraulic power package for steering.

SIMPLIFIED INSTALLATION

This compact and complete power package is easily and quickly installed. All you need to do is bolt it on, make two hydraulic connections, and couple the power.

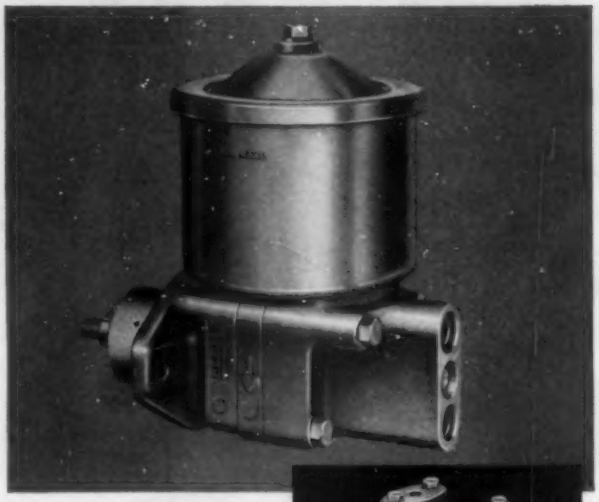
LONGER PUMP LIFE

The exclusive Vickers "Hydraulic Balance" eliminates pressure-induced bearing loads and the consequent wear. These lighter bearing loads mean much longer bearing and pump life.

NO LOAD STARTING

At rest and normal starting speeds, the sliding vanes are retracted; only after engine fires do vanes extend and pumping begin.

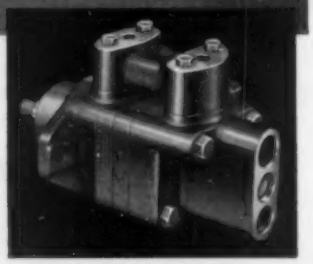
ASK FOR BULLETIN M-5104A



Series VT16 Vickers Pump with integral volume control and relief valves and oil reservoir. For hydraulic power steering.

HIGH OPERATING EFFICIENCY

The vane type construction, hydraulic balance and automatic maintenance of optimum running clearances enable these pumps to deliver more oil with less power. This high operating efficiency is maintained throughout the long pump life.



Series VT17 Vickers Pump is similar to the VT 16 except that it does not include the oil reservoir.

VICKERS Incorporated

DIVISION OF THE SPERRY CORPORATION

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Application Engineering Offices: ATLANTA • CHICAGO (Metropolitan) • CINCINNATI • CLEVELAND • DETROIT • HOUSTON LOS ANGELES (Metropolitan) • NEW YORK (Metropolitan) • PHILADELPHIA (Metropolitan) • PITTSBURGH • ROCHESTER • ROCKFORD • SEATTLE • TULSA • WASHINGTON • WORCESTER

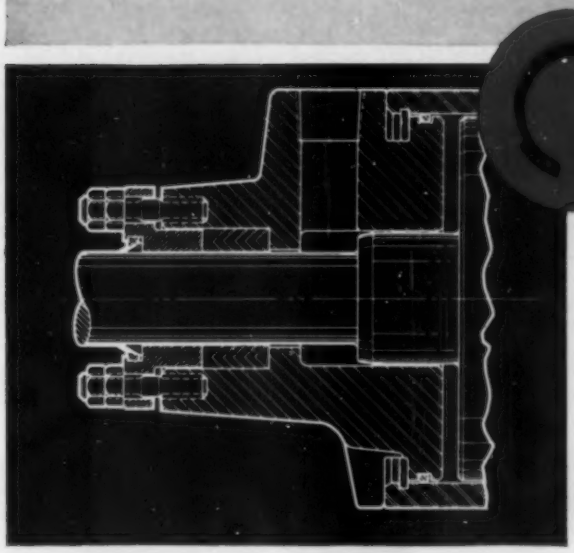
VICKERS® HYDRAULIC POWER STEERING BOOSTER

EFFORTLESS • POSITIVE • SHOCKLESS

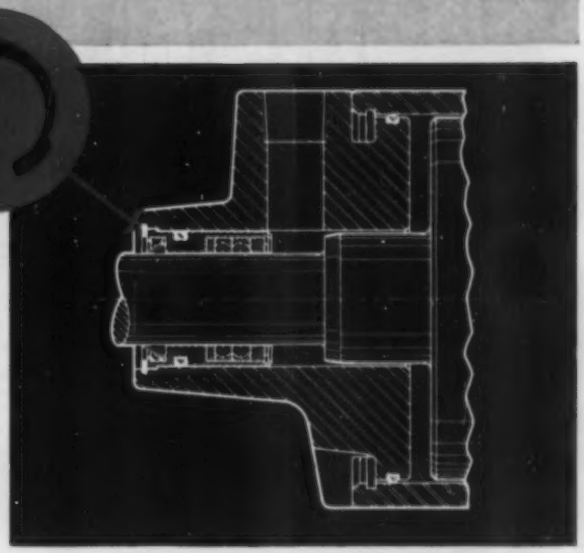
6726

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Waldes Truarc Ring Saves $2.84 Per Unit, Cuts Labor-Time and Materials in Hydraulic Packing Unit



OLD STYLE stuffing box required skilled worker to install packing rings one at a time, then adjust packing glands by trial and error. Disassembly was equally difficult, time-consuming and costly.



NEW Monopak Cartridge is smaller, lighter, streamlined and installed with one Truarc Retaining Ring. Disassembly and reassembly with new cartridge takes unskilled worker just 1 minute.

Hydraulic Accessories Company of Van Dyke, Michigan, uses a single Waldes Truarc Inverted Ring (internal series 5008) to hold Monopak Cartridge in cylinder head.

New design eliminates costly machining and saves 2⅛ lbs. of material. Re-design with Waldes Truarc Retaining Ring reduces stuffing box diameter from 3½" to 2⅞", and reduces length from 5⅞" to 4⅜". Allows savings in assembly, adjusting and testing.

NEW DESIGN USING WALDES TRUARC RING PERMITTED THESE SAVINGS PER UNIT

MACHINE TIME SAVED:	
Chucking, facing and boring	$ .72
Drilling and tapping 3 holes	.18
Drilling and counterboring 3 holes	.12
Assembling, adjusting, testing	.90
MATERIAL SAVED:	
1⅛ lbs. cast iron	.30
⅛ lb. bronze	.23
3 studs	.36
3 nuts	.03
TOTAL	$2.84

Waldes Truarc Retaining Rings are precision-engineered . . . quick and easy to assemble and disassemble. Always circular to give a never-failing grip. They can be used over and over again. There's a Waldes Truarc Ring to answer every fastening problem.

Find out what Waldes Truarc Retaining Rings can do for you. Send your blueprints to Waldes Truarc engineers for individual attention, without obligation.

For precision internal grooving and undercutting . . . Waldes Truarc Grooving Tool. "See the Waldes Truarc exhibit at the A.S.T.E. Show, April 26-30. Booth No. 424, Precision Hall."

SEND FOR NEW CATALOG

WALDES

TRUARC

REG. U. S. PAT. OFF.

RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS AND PLIERS ARE PROTECTED BY ONE OR MORE OF THE FOLLOWING U. S. PATENTS: 2,382,947; 2,382,948; 2,416,052; 2,420,921; 2,420,341; 2,439,705; 2,441,848; 2,455,165; 2,465,380; 2,483,303; 2,487,902; 2,487,903; 2,491,300; 2,509,081 AND OTHER PATENTS PENDING

Waldes Kohinoor, Inc., 47-16 Austel Place, L.I.C. 1, N.Y.

Please send me the new Waldes Truarc Retaining Ring catalog.

PX-046

(Please print)

Name.....

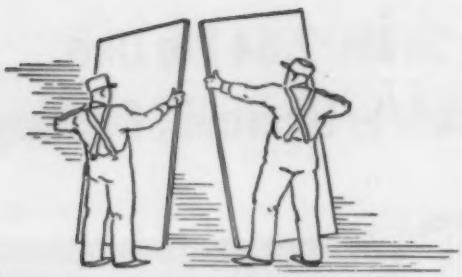
Title.....

Company.....

Business Address.....

City..... Zone..... State.....

★



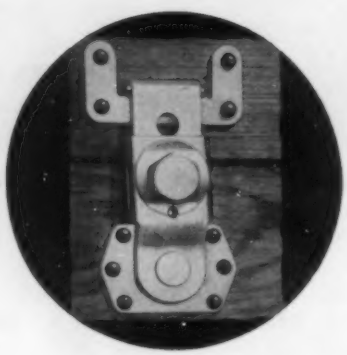
Have you a similar fastening problem?

How a strong structure can be designed for speedy and simple assembly with unskilled labor, no special tools...

The U. S. Air Force wanted a jet-aircraft hangar design that would be portable by air, yet strong; would assemble quickly; be interchangeable, and flexible enough for easy structure modification.

The answer lay in a panel structure using modular units. Armorply honeycomb panels faced with thin aluminum, developed by United States Plywood Corporation, provide lightness, strength, flexibility. Joining one panel to the other in the field with untrained help was a problem until Simmons Fastener developed LINK-LOCK, a simple latching device that operates with minimum wrench pressure on hex nut.

This fastening problem is being successfully met by combining the design ingenuity of No. 1 LINK-LOCK with the proved performance of honeycomb plywood panels.



No. 1 LINK-LOCK—like No. 2 LINK-LOCK—features simplicity, positive action, high strength.

No springs are used in No. 1 LINK-LOCK. Locking action is obtained by rotating a nut that moves a sliding latch in and out of position. Up to 1500-lb. pull-down pressure is available; the device carries up to 4000-lb. tension. No. 1 LINK-LOCKS provide for surface mounting, simplifying installation.

Where can you use it? When you need heavy fastening pressures, resistance to impact, operation in 70-below temperatures—and where ease of action, compactness, and low cost are important factors. Write for a No. 1 LINK-LOCK Data Sheet.

SIMMONS FASTENER CORPORATION
1751 No. Broadway, Albany 1, New York

FASTENERS THAT IMPROVE PRODUCTS AND REDUCE ASSEMBLY COSTS

Simmons QUICK-LOCK SPRING-LOCK ROTO-LOCK LINK-LOCK DUAL-LOCK

JUST OUT! NEW 36-PAGE CATALOG WITH APPLICATIONS. SEND FOR IT!

Achieves high production, high precision of difficult jet engine part

...with help of TIMKEN® bearings

TO insure high-speed precision machining of compressor discs for the J-34 turbo-jet engine, four Gisholt 4F Fastermatic Automatic turret lathes are set up in a two-man "production line". Each operator tends two lathes and they perform all machining in four pass-along operations.

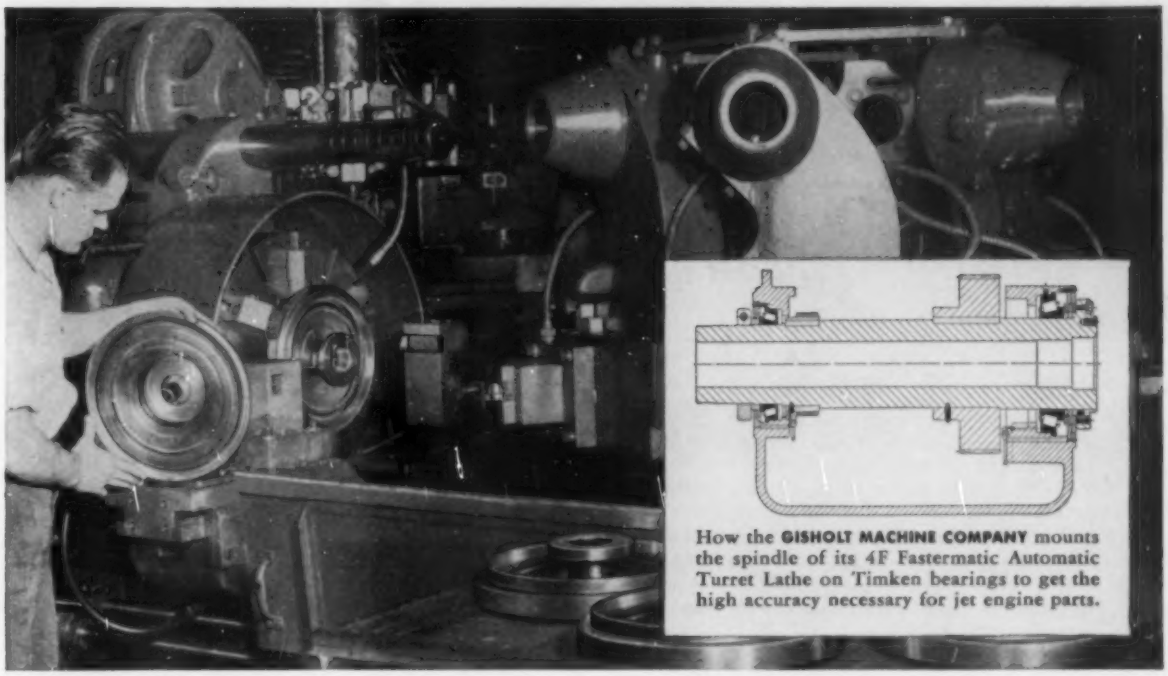
Just what these operations are, and the time it takes, are classified information, but it's no secret that it's a particularly tough assignment. These stainless steel compressor discs have a complicated shape, and must be held to extremely close tolerances.

Gisholt makes sure these lathes operate with high precision by mounting the spindle and gear train on Timken® tapered roller bearings. The spindle has adequate capacity for any load; line contact between rollers and races of Timken bearings provides load-carrying capacity to spare. And the tapered design of Timken bearings enables them to take radial and thrust loads in any combination. This holds spindles rigid and permits pre-loading to any desired degree to prevent chatter.

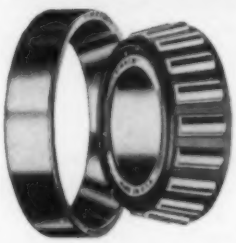
Timken bearings practically eliminate friction because of their true rolling motion and smooth surface finish. Made from Timken fine alloy steel—finest steel ever developed for tapered roller bearings—Timken bearings' rollers and races are case hardened for hard, wear-resistant surfaces and tough, shock-resistant cores. As a result, wear is reduced, maintenance minimized.

Next time you buy or build a machine tool, make sure it's equipped with Timken precision tapered roller bearings. Always look for the trade-mark "Timken" stamped on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



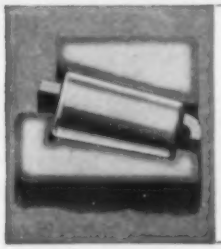
How the **GISHOLT MACHINE COMPANY** mounts the spindle of its 4F Fastermatic Automatic Turret Lathe on Timken bearings to get the high accuracy necessary for jet engine parts.



TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS



GREATER LOAD AREA

Because the load is carried on the *line* of contact between rollers and races, Timken bearings carry greater loads, hold shafts in line, wear longer.

The Timken Roller Bearing Company is the acknowledged leader in: 1. advanced design; 2. precision manufacturing; 3. rigid quality control; 4. special analysis Timken steels.

NOT JUST A BALL — NOT JUST A ROLLER — THE TIMKEN TAPERED ROLLER — BEARING TAKES RADIAL AND THRUST — LOADS OR ANY COMBINATION

IF YOUR PRODUCT DESIGN INVOLVES HYDRAULIC POWER

specify

PESCO *Pressure Loaded* PUMPS

There's only one *best* hydraulic pump for any job—*and it's PESCO!* On thousands of hydraulic applications with capacities up to 60 gpm and pressures to 3000 psi, PESCO Pressure Loaded PUMPS have proved to be the *one best* answer to continuous peak performance.

When your requirement calls for dependable hydraulic performance with life-long peak efficiency, you'll want PESCO. And when your problem involves hydraulic power, you'll want to make use of the outstanding PESCO Hydraulic Engineering Service—with specialists in YOUR hydraulic problems. It's yours without obligation--simply call or write the Home Office, Bedford, Ohio.

DEPENDABLE PERFORMANCE
CONTINUOUS NEW PUMP EFFICIENCY
AUTOMATIC ADJUSTMENT FOR WEAR
LESS UNIT SPACE REQUIRED
LOWEST LIFETIME COST

Call or write the Home Office, Bedford, Ohio for full information on these outstanding PESCO PRODUCTS
HYDRAULIC PUMPS • POWER-PACKAGES
HYDRAULIC MOTORS • ELECTRIC MOTORS
CONTROLS AND VALVES

engineering Pesco production
PRODUCTS DIVISION

PRODUCING THE BEST IN HYDRAULIC EQUIPMENT AND ELECTRIC MOTORS

BORG-WARNER CORPORATION
24700 NORTH MILES ROAD • BEDFORD, OHIO

DOW CORNING
SILICONES

give motors more muscles

RELIANCE 20 hp (class H) Motor
330 Pounds Lighter than Conventional Design

For maximum safety, carrier planes are fueled and defueled immediately before take-off or after landing. Several fast reversible pumps are used, any of which can fill or empty a plane's tanks within minutes. The pumps and their motors are big and heavy, however. So much so that the Navy challenged manufacturers to produce new motors which would combine top dependability and absolute minimum weight.

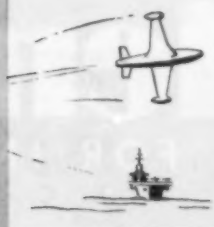
The Reliance Electric & Engineering Company attacked the problem both inside and out. They made the entire TENV frame and the mounting brackets of aluminum, ribbed for maximum heat dissipation. On the inside, silicone (Class H) insulation raises the power-per-pound ratio by over 50%, and also provides extra resistance to weathering and salt spray. As a result, the finished motors are among the smallest and lightest ever made in their class. The 20 hp unit, for example, weighs some 330 pounds less than the conventional 20 hp motor. Already they have been specified for the new super carriers Forrestal and Saratoga.

That's typical of the "design-ability" of Class H insulation made with Dow Corning silicones. Adaptable to any electrical equipment and costing only slightly more than the next best class of insulation, it can be used to increase the power-per-pound ratio or to extend the life of electrical machinery over ten times. For better performance, lower maintenance costs, and greater sales appeal, alert design and management men specify Class H insulation made with Dow Corning silicones

first in silicones

DOW CORNING
CORPORATION

MIDLAND, MICHIGAN



mail this coupon today!

Dow Corning Corporation, Dept. R-16, Midland, Michigan
Please send me

- ☐ List of Class H rewind shops
- ☐ More performance data on Class H
- ☐ List of Class H Motor and
- ☐ Class H Transformer Manufacturers
- ☐ "Tall Tales and Fabulous Facts" about silicone products

NAME _____ TITLE _____

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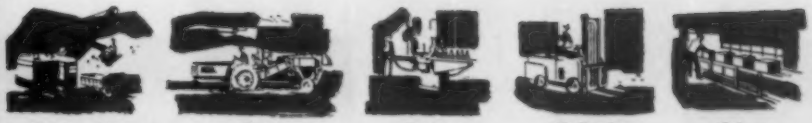
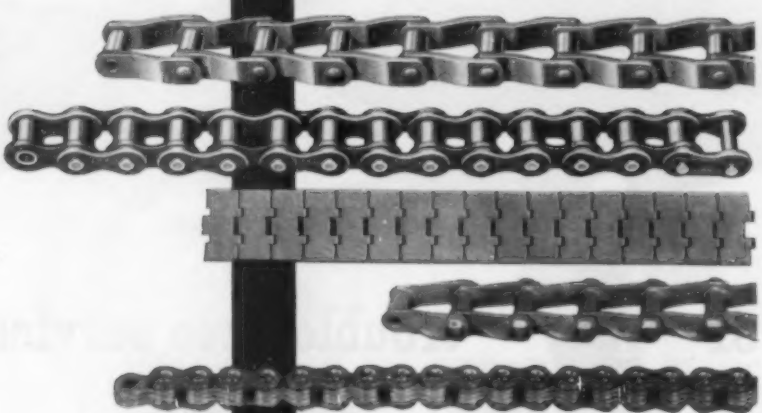


with these dvantages

t only CHAINS give you!



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Your Chain Belt Field Sales Engineer will be happy to help you select the size and type of chain and sprocket that will best suit your needs . . . provide the most efficient drive or conveyor at the lowest cost. Call him or mail the coupon today.

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Send literature on: ☐ Chabelco Chains; ☐ Roller Chains; ☐ TableTop; ☐ Leaf Chains; ☐ Cast Chains; ☐ Sprockets. ☐ Have a Chain Belt Man call.

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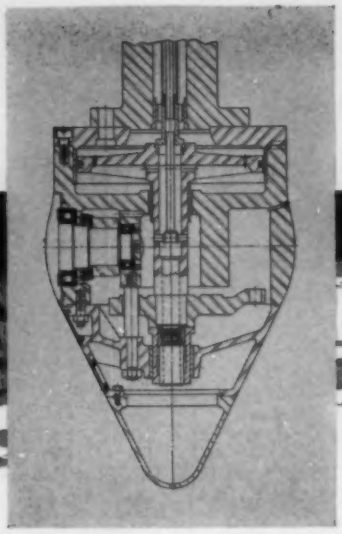
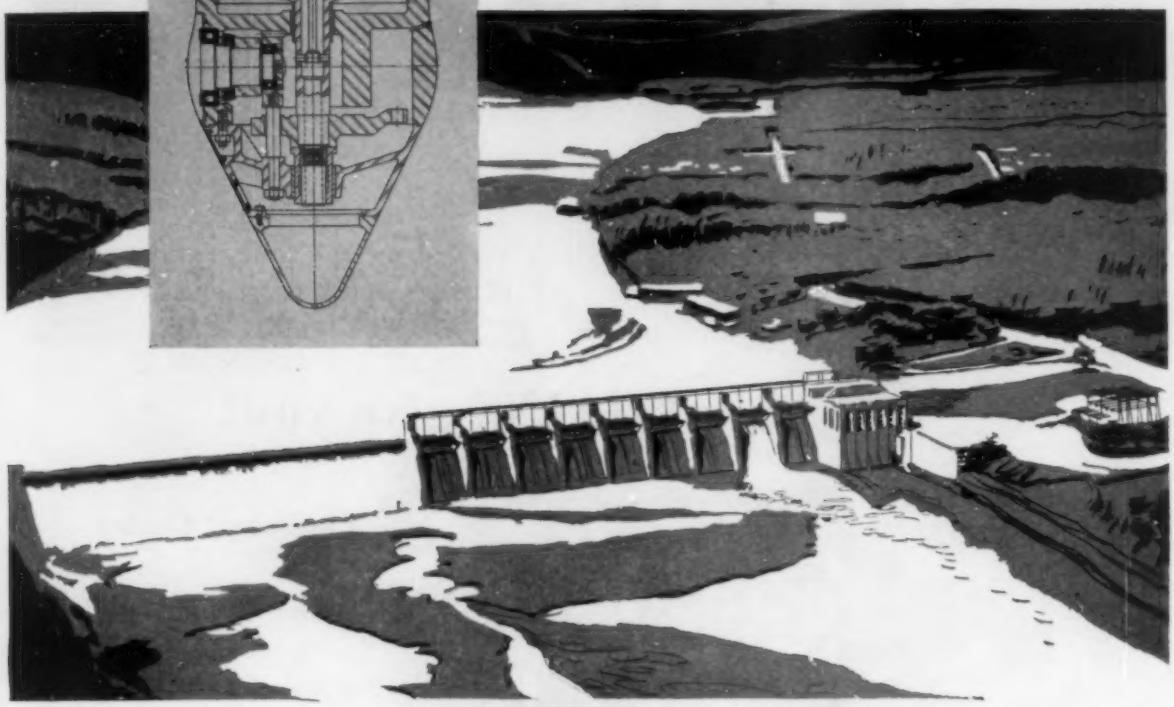
City.....*Zone*.....*State*.....

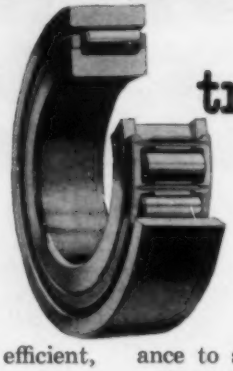
TORRINGTON BEARINGS AT WORK



TORRINGTON Radial Roller Bearings and Roller Thrust Bearings installed in turbine-blade runner hubs at Texas' Austin Dam demonstrate the versatility and efficiency of precision-ground TORRINGTON Bearings. Installation by Newport News Shipbuilding & Drydock Company.



Fifteen years of trouble-free service!



The two Newport News adjustable blade turbines installed at Texas' Austin Dam in 1939 were equipped with TORRINGTON Bearings in the runner hubs. Today, *fifteen years later*, those bearings are still giving efficient, trouble-free service.

And little wonder. For TORRINGTON Bearings are precision ground from the finest of bearing-quality steels. They are carefully heat treated by the most advanced metallurgical methods. In most designs their one-piece cages are cast of bronze and are *land-riding*.

In every kind of heavy-duty application, TORRINGTON Bearings assure high load-carrying capacity, maximum rolling efficiency and resistance to shock and wear.

Next time you specify bearings, choose TORRINGTON. You'll find the type to meet your requirements.

THE TORRINGTON COMPANY
South Bend 21, Ind. Torrington, Conn.

TORRINGTON RADIAL ROLLER BEARINGS

Spherical Roller • Tapered Roller • Cylindrical Roller • Needle • Ball • Needle Rollers

LOWER COSTS,
PLUS PRODUCT ADVANTAGES WITH
T and W
DEEP DRAWN STAMPINGS

15½" Dia.
3" Deep
16 Ga.

12" Wide x
16½" Long,
10¾" Deep.
10 Ga.

16½" Wide, 27⅜" Long,
6" Deep (Deep End).

Deep drawn stampings by Transue have helped numerous manufacturers to low costs . . . in addition, light weight, strength, shock resistance and improved appearance of products. A T & W stamping specialist will gladly consult with you.

For those manufacturers having their own press equipment Transue will gladly quote on die requirements.

Transue & Williams

ALLIANCE, OHIO

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Carpenter **Stainless Tubing...**

doesn't cost ...IT PAYS

...in time-saving fabrication, cost-cutting corrosion resistance, and extended service life.

It's this way. There's a difference in stainless tubing quality and uniformity—and Carpenter makes it. Pictured here are three random examples. Hundreds more are on file from design engineers, equipment fabricators and plant engineers citing how the difference in Carpenter Stainless Tubing pays off in product improvement, easier fabrication, lower production and maintenance costs, and more freedom from costly equipment "down-time".

In short, you buy all-around stainless tubing satisfaction when your buy-word is Carpenter. Be sure to contact your nearby Carpenter Distributor or Branch Office next time you have a requisition for stainless tubing. You can count on prompt service on your requirements and experienced technical help in selecting and fabricating your tubing.

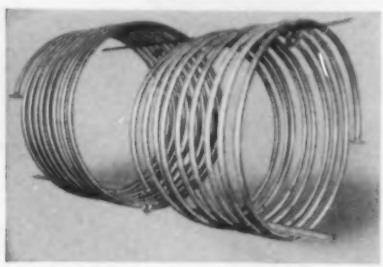
The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

Branch Offices: Atlanta Chicago Pittsburgh Houston Newark San Francisco

Export Dept.: The Carpenter Steel Co., Port Washington, N. Y. "CARSTEELCO"

FOR PARTS—on this tough flaring job, two brands of stainless tubing were tried with 50% rejects. After switching to Carpenter, rejects dropped to less than 1%!

FOR PRODUCTION EQUIPMENT—ten cooling coils like this were made from Carpenter Stainless Tubing at a saving in material of about $1000 because uniform walls permitted using a lighter gauge.



FOR SUPER CORROSION RESISTANCE—coil life in a hydrolysis tank was more than doubled by switching from lead to Carpenter Stainless No. 20.

Carpenter

STAINLESS TUBING & PIPE

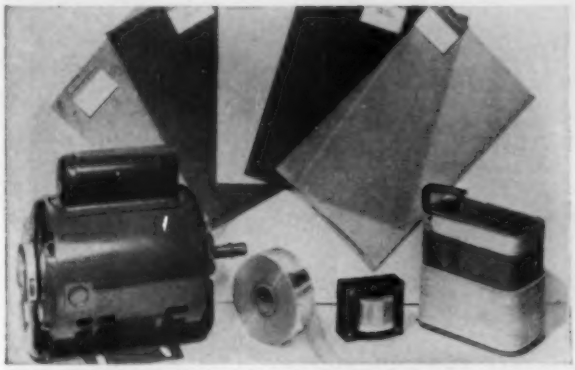
• guaranteed on every shipment

new Du Pont MYLAR

REG. U. S. PAT. OFF.

OPENS NEW ENGINEERING POSSIBILITIES FOR AN AMAZING VARIETY OF PRODUCTS

It's tissue-thin . . . yet strongest of all plastic films



FOR LAMINATION, "Mylar" is tough, durable, chemically resistant . . . finding uses in combination with a wide variety of other materials.

FOR ELECTRICAL INSULATION, the balance of properties offered by "Mylar" permits insulation that takes up less space . . . resists extremes of temperature and humidity.

BONDED TO FOILS, "Mylar" makes a tough, brilliant thread for weaving into textiles . . . makes practical many new fabric designs.

AS A TAPE, "Mylar" offers high tensile strength . . . is dimensionally stable. It is being used for recording tapes and a variety of industrial tapes.

Out of Du Pont research comes a new film—"Mylar" polyester film—with properties so unusual that it can do an amazing variety of jobs. Many of its uses, in fact, are outside the fields where plastic films are now prominent.

"Mylar" has exceptional tensile and impact strength. Thus it can be made in gauges as thin as 0.00025 inch.

Electrically, "Mylar" has high dielectric strength and a relatively low power factor. These properties, together with its outstanding mechanical properties and thermal stability, make it ideal for a variety of insulating purposes . . . permit miniaturization of electrical equipment.

Tough, durable and greaseproof, "Mylar" can be used for industrial tapes . . . thermal insulation protection. It can be combined with foils, papers, plastics . . . opening new possibilities in the design of protective and decorative laminates and other materials.

These are only a few of the applications now being tested for this remarkable film. There's no question that you'll be seeing more of "Mylar"—and doing more with it—in the near future. Why not investigate its possibilities for *your* products right now? Write for further information to: E. I. du Pont de Nemours & Co. (Inc.), Film Department, Room P, Wilmington 98, Delaware.

DU PONT "MYLAR"

Polyester Film

DU PONT

REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

HEAVY-DUTY CURTAIN TRACK made from Cold-Formed Shapes

Bethlehem Cold-Formed Shapes can be welded without special preparation because of the smooth, relatively scale free surface.

This Bethlehem Cold-Formed Shape has gone to work in school auditoriums, television studios, theaters and other places where heavyweight curtains and draperies are required to move quickly and quietly across a stage.

Curtain tracks made from 14-gage Cold-Formed Shapes are fulfilling every requirement. We can supply these shapes in practically any length the manufacturer specifies, so that the tracks can be in one continuous piece, free of joints. And the virtually scale-free surfaces provide smooth, parallel treads on which the bearing carriers roll.

Curtain tracks are only one among hundreds of shapes we have turned out for such diversified items as sign-supports, rub-rails for bus bodies, and parts for lawn mowers.

Bethlehem Cold-Formed Shapes are regular or irregular shapes formed cold from strip, sheet or plate steel. They are uniform in thickness, relatively scale-free, and have a high strength-to-weight ratio. We make them on presses, brakes or rolls, in all gages from 5 to 24.

Perhaps you have an idea which could be developed into a practical, cost-cutting use for cold-formed shapes. If so, tell us about it. Write direct to us at Bethlehem, Pa., including, if possible, a rough sketch of the part you have in mind.

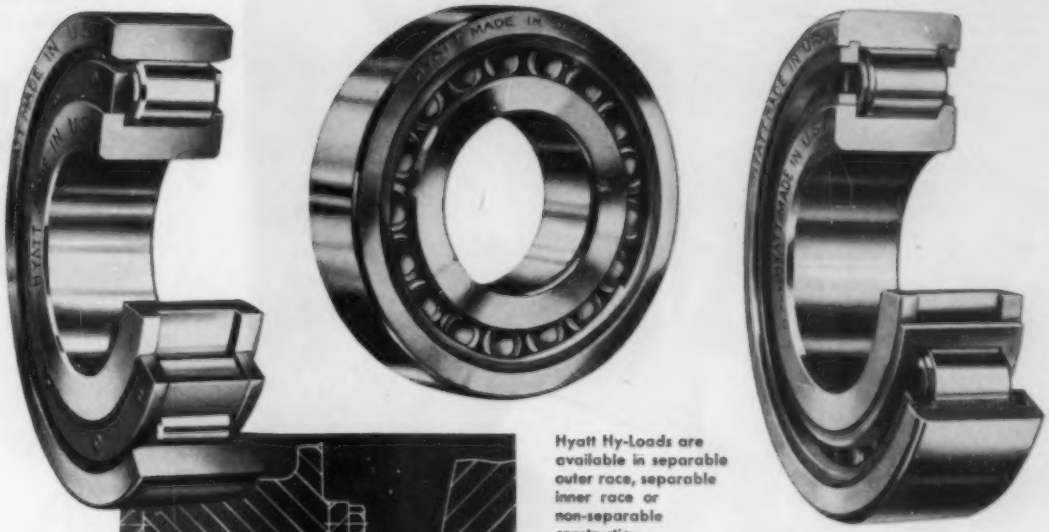
BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

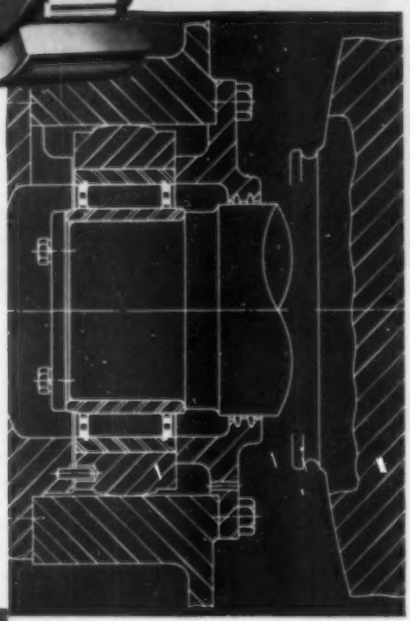
BETHLEHEM STEEL

Is shaft expansion a problem?

HERE'S HOW HYATTS HELP...



Hyatt Hy-Loads are available in separable outer race, separable inner race or non-separable construction.



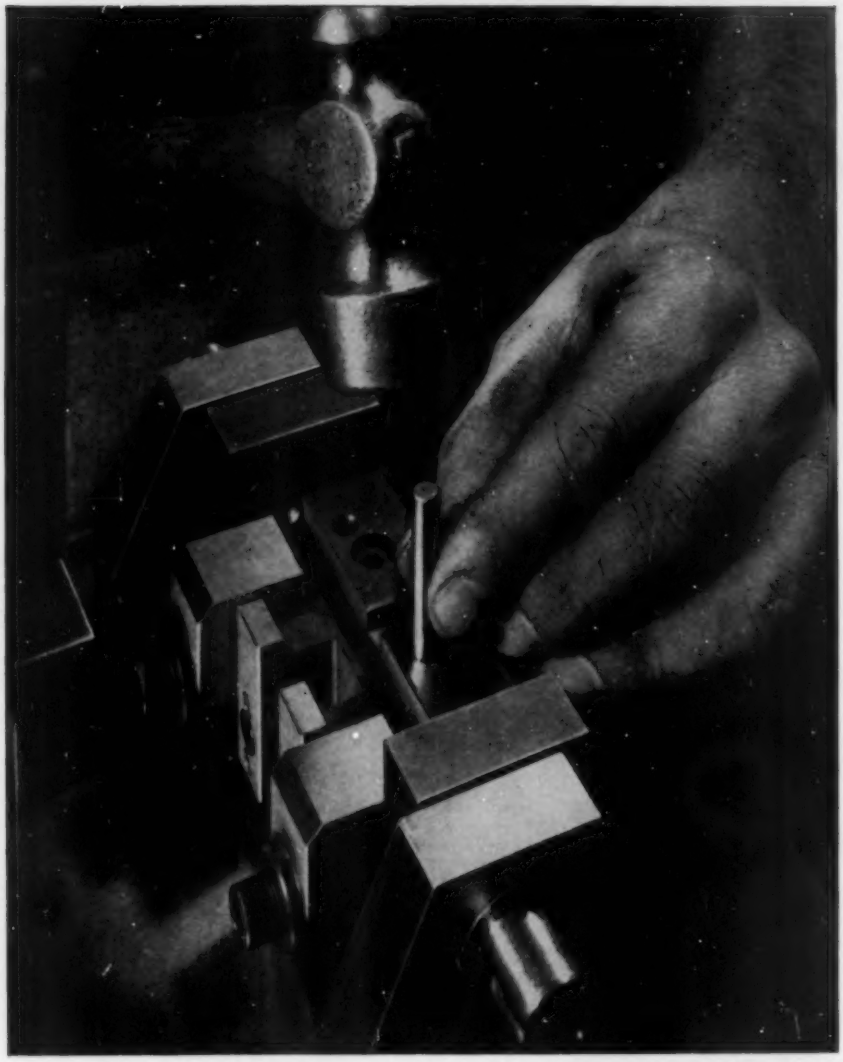
Check the drawing at the left. The bearing is a Hyatt Hy-Load, and because the inner race is cylindrical, the shaft it supports is free to move axially—thus allowing for shaft expansion without cramping the bearing or distorting the shaft. Obviously, this is only one of many ways in which Hyatt bearings can be used to reduce costs as they reduce friction, but it's a good example of why so many designers throughout industry keep their Hyatt catalogs within easy reach.

For further details write for Catalog 150 or call your nearest Hyatt representative.

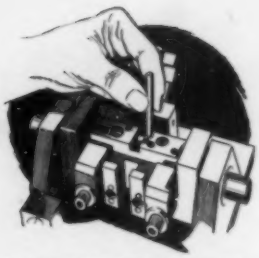
HYATT ROLLER BEARINGS

STRAIGHT BARREL TAPER

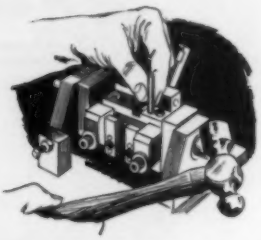
HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION • HARRISON, NEW JERSEY



UNBRAKO Precision-Ground Dowel Pins are widely used for aligning parts, as in dies, jigs and fixtures. This radius grinding fixture, for putting a flat on electronic shafting, is a good example of such an application.



Assembler inserts formed end of UNBRAKO dowel pin into hole preparatory to tapping it into position.



Formed ends, with continuous grain flow, won't chip. Uniform heat treatment permits UNBRAKO dowel pins to be driven in and out of holes without upsetting.

UNBRAKO dowel pins—made of heat treated alloy steel—have a surface hardness of 60-62 Rockwell "C" Scale; a surface finish of 6 microinch maximum; a core hardness of 50-54 Rockwell "C" Scale; an average single shear strength of 150,000 psi; and a diameter tolerance of ±0.0001". They are available in two standard sizes in diameters from ⅛" to 1".

Keep your inventory at a minimum
Use UNBRAKO Standards—stocked by your distributor

Because your UNBRAKO distributor stocks a full line of standard UNBRAKO socket screw products, your inventory is lowered. This ready supply not only cuts your investment, but gives you faster delivery and reduces your buying costs. For a complete listing of standard UNBRAKO products, see your distributor or write STANDARD PRESSED STEEL CO., Jenkintown 28, Penna.

See us at Booth 1539, Convention Hall, Philadelphia, Pa., during the A.S.T.E. Show, April 26 to 30.

UNBRAKO® SOCKET SCREW DIVISION

SPS JENKINTOWN PENNSYLVANIA

...solid foundation
FOR TODAY'S COMPACT MOTOR DESIGN
There are, as you know, new NEMA Standards for electric motors ... more power in less space
When you look for a new NEMA frame motor, look for the one that is built on a solid foundation ... it carries the Fairbanks-Morse Seal of Quality.
The Standards are new .. But the Idea Is Not
Like the recent Fairbanks-Morse developments in other lines, the new F-M motor is the result of a basic engineering philosophy: More Performance in Less Space—a 120-year tradition at Fairbanks-Morse. Fairbanks, Morse & Co., 600 South Michigan Avenue, Chicago 5, Illinois
FAIRBANKS-MORSE
a name worth remembering when you want the best
ELECTRIC MOTORS AND GENERATORS • DIESEL LOCOMOTIVES AND ENGINES • PUMPS • SCALES • RAIL CARS • HOME WATER SERVICE EQUIPMENT • FARM MACHINERY • MAGNETOS
NEW LOCOMOTIVE DESIGN
NEW GENERATOR DESIGN
NEW DIESEL DESIGN
NEW MOTOR DESIGN
NEW SCALE DESIGN
NEW MAGNETO DESIGN
NEW PUMP DESIGN
NEW

they thought this die casting couldn't be made...

● But **Stewart** turned out over 12,000 a week!

This helical gear is one example of an old habit at Stewart Die Casting—"finding a way." In 44 years, we have produced many castings that "couldn't be made." Whatever type of die castings you need—small or large, simple or intricate—count on *Stewart* to meet your most rigid specifications . . . on time.

SERVICES AVAILABLE . . .

Designing • Engineering • Die Making Metallurgical Control • Most Modern Die Casting Equipment • Complete Machining, Polishing and Assembly Facilities.

44 years of helping industry to "Make It Better"

Stewart DIE CASTING

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New facts for your file on

USS CARILLOY STEELS

USS Carilloy steel passes rigid tests for propeller blades

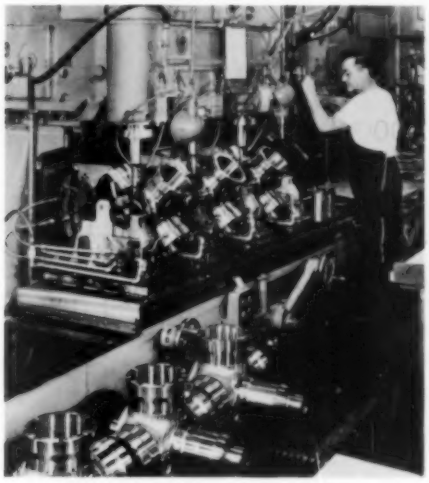
● An important manufacturer of propellers for military aircraft has found that in stringent magnaflux tests, USS CARILLOY steel performs completely satisfactorily.

The high stresses in propeller blades and hubs naturally require extremely high quality steels. Accordingly, the U.S. Army and U.S. Navy have set up rigid quality specifications requiring that every heavily stressed part must be magnafluxed several times during its production.

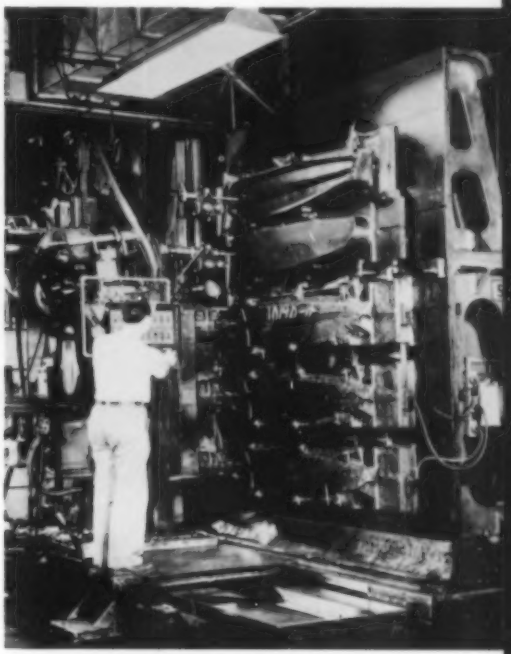
With USS CARILLOY 4340 electric furnace aircraft quality steel, this important manufacturer is able to count on the performance required for this severe application. The consistent high quality of USS CARILLOY aircraft steel has meant greater savings to this customer through minimum magnaflux rejections of costly fabricated parts.

USS CARILLOY steels have established an enviable record for meeting the highest quality requirements. Therefore, when you need a standard AISI analysis or a special steel for an unusual application, it pays to call in a USS Service Metallurgist. He can help you solve any steel problem.

FOR BIG PROPELLERS, 2 forged sections (a) are welded together to form one blade thrust member. Pieces are then ground and magnafluxed, Kellered, ground, and magnafluxed again (b). Mill camber sheets (c) then are copper brazed to the thrust members. Entire unit is heat treated and polished before final magnaflux test and cadmium plating. Rigorous magnaflux testing assures that every finished blade (d) can withstand the tremendous stresses encountered on the latest high-speed planes.



THESE HIGH QUALITY aircraft propeller hubs are forged and machined from semifinished CARILLOY 4340. They meet extremely tough magnaflux requirements.



AFTER FORGING AND MILLING, 750-lb. thrust sections are hogged out on this Kellering machine. Finished sections weigh about 155 lbs. USS CARILLOY steel maintains a No. 1 quality position on these heavy-duty parts.

USS

UNITED STATES STEEL CORPORATION, PITTSBURGH · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO

TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. · UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST

UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

New facts for your file on

USS STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

Solids removed from potash brine in centrifugals of Stainless Steel

THIS STAINLESS STEEL centrifugal filter at International Minerals and Chemical Corporation, Carlsbad, N. M., handles 10 tons of 60% muriate crystals per hour. It was manufactured by Bird Machine Company, South Walpole, Mass.

● Processing potash from the salt beds near Carlsbad, N. M., puts centrifugal filters to a severe test. That's why much of this equipment is made of Stainless Steel.

The potash brine is highly corrosive and the solids to be recovered are very abrasive. As a result, Bird Machine Company, South Walpole, Mass.—which supplies many of the centrifugals for this type of application—uses Stainless Steel for rotating parts and other parts of the filters that come in contact with the material.

Filters built of Stainless have handled many thousands of tons of these materials—separating and dewatering the crystalline solids—with high efficiency and overall economy.

Lake steamer cafeteria is fabricated from Stainless Steel

The attractive appearance, excellent sanitary qualities and long life of Stainless Steel have gained a wide range of food handling jobs for this durable material.

N. Wasserstrom and Sons, Incorporated, Columbus, Ohio, in fabricating cafeteria equipment for a Great Lakes steamer, used Stainless Steel very extensively. The result is an installation that looks well, cleans easily and lasts almost indefinitely.

STAINLESS STEEL was used extensively in this cafeteria installation for a lake steamer. The installation was fabricated by N. Wasserstrom and Sons, Incorporated, Columbus, Ohio.

MANUFACTURED FROM USS STAINLESS STEEL UNITED STATES STEEL

Now is the time to use the sales appeal of Stainless Steel

The many benefits of Stainless Steel make its use in your product a real "plus" from a sales standpoint. Its lasting good looks alone will often justify its use. And, along with this important advantage, goes exceptional resistance to corrosion and abrasion, ease of cleaning and low maintenance costs.

There's never been a better time to take advantage of the qualities of Stainless Steel. And when you do, be sure that perfected, service-tested USS Stainless Steel is used.

UNITED STATES STEEL CORPORATION, PITTSBURGH · AMERICAN STEEL & WIRE DIVISION, CLEVELAND · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
NATIONAL TUBE DIVISION, PITTSBURGH · TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. · UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
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UNITED STATES STEEL

USS

New facts for your file on

USS HIGH STRENGTH STEELS

USS HIGH STRENGTH STEELS — UNITED STATES STEEL — 1933 1953 — TWENTY YEARS OF PERFORMANCE

USS COR-TEN steel gives heavy-duty earth moving equipment the stamina to stay on the job

• By building maximum strength and durability into parts ordinarily prone to failure, Allis-Chalmers, through the use of USS COR-TEN steel, has ensured a high degree of productivity and profitable performance for their TW-300 Motor Wagon.

Used in the sides, ends and bottoms of the bowl of this big capacity hydraulically operated bottom dump wagon, COR-TEN steel increases strength 50% over carbon steel construction, provides 50% higher fatigue strength, materially increases resistance to abrasion and to sudden blows in loading. An added advantage is increased resistance to atmospheric corrosion—4 to 6 times that of carbon steel.

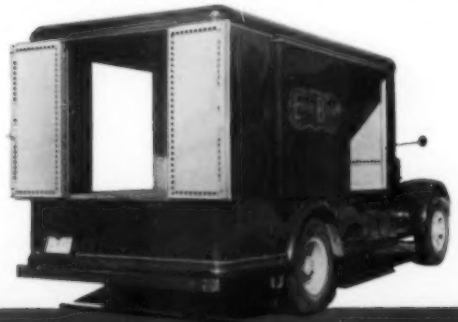
As a result, breakdowns and time-out for repairs are reduced to a minimum, as are maintenance and replacement costs.

In mass-produced truck body members, USS COR-TEN steel saves weight, adds strength, facilitates accurate construction

By mass-producing standardized truck body shapes and sections that can be readily and quickly assembled, Parish Pressed Steel Company, Reading, Pa., has made it possible for local body builders to turn out steel truck bodies to meet individual truck owners' requirements at high speeds and low cost.

The use of USS COR-TEN high strength steel in these prefabricated body sections not only permits light, strong and very durable construction, but because of the high physical properties of this steel and its consistent uniformity, it is possible to hold designs to exact limits and very close tolerances. Over-all results are much better than when less efficient materials are used.

With USS COR-TEN steel construction like this, the body builder benefits because his operations are speeded up and his assembly costs are reduced. The truck owner benefits because he gets a truck that, while light in weight, has maximum strength and durability, is readily repaired if damaged and requires minimum maintenance.



New catalog gives complete story of USS COR-TEN steel

Here are 58 pages of factual data that show the substantial economies that can be affected in equipment and structures by using USS COR-TEN steel to reduce weight or to increase durability and service life. This book is just off the press. Crammed with information, it should be in the reference files of every designer. It fully describes the properties and characteristics of USS COR-TEN steel. Its many illustrations show the wide variety of applications in which this superior high-strength steel has been used to reduce operating costs and to keep maintenance costs at a minimum. Send for your copy.

UNITED STATES STEEL CORPORATION, PITTSBURGH · AMERICAN STEEL & WIRE DIVISION, CLEVELAND · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
NATIONAL TUBE DIVISION, PITTSBURGH · TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. · UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
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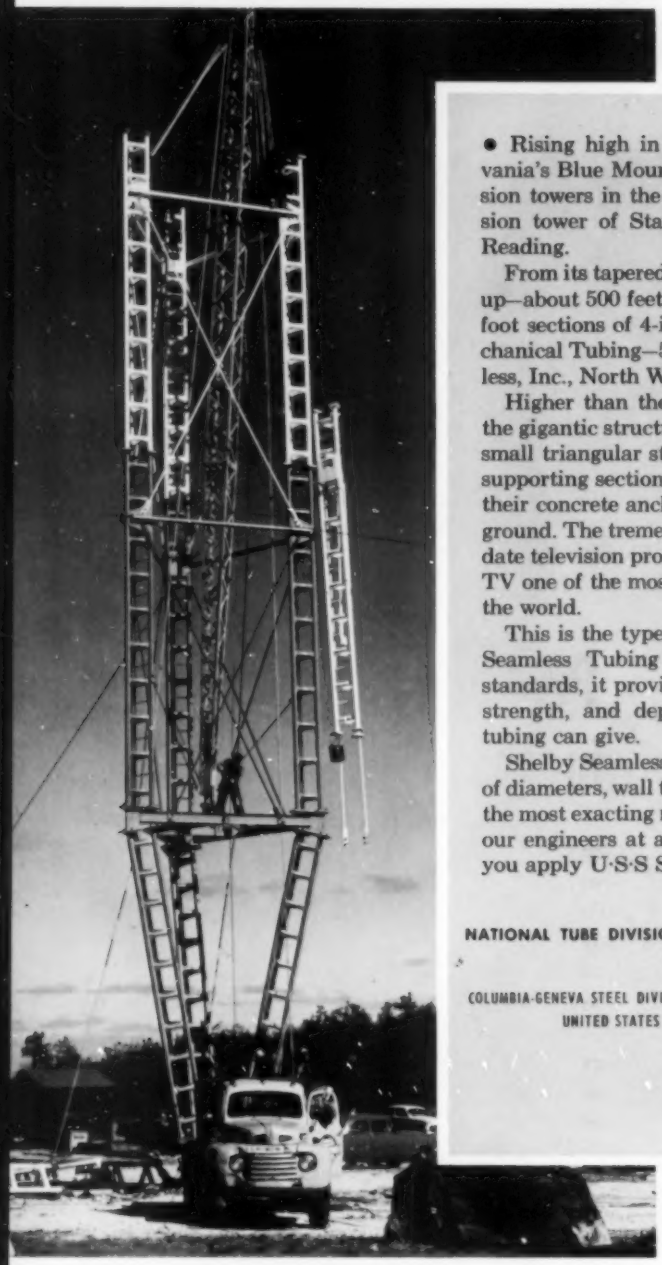
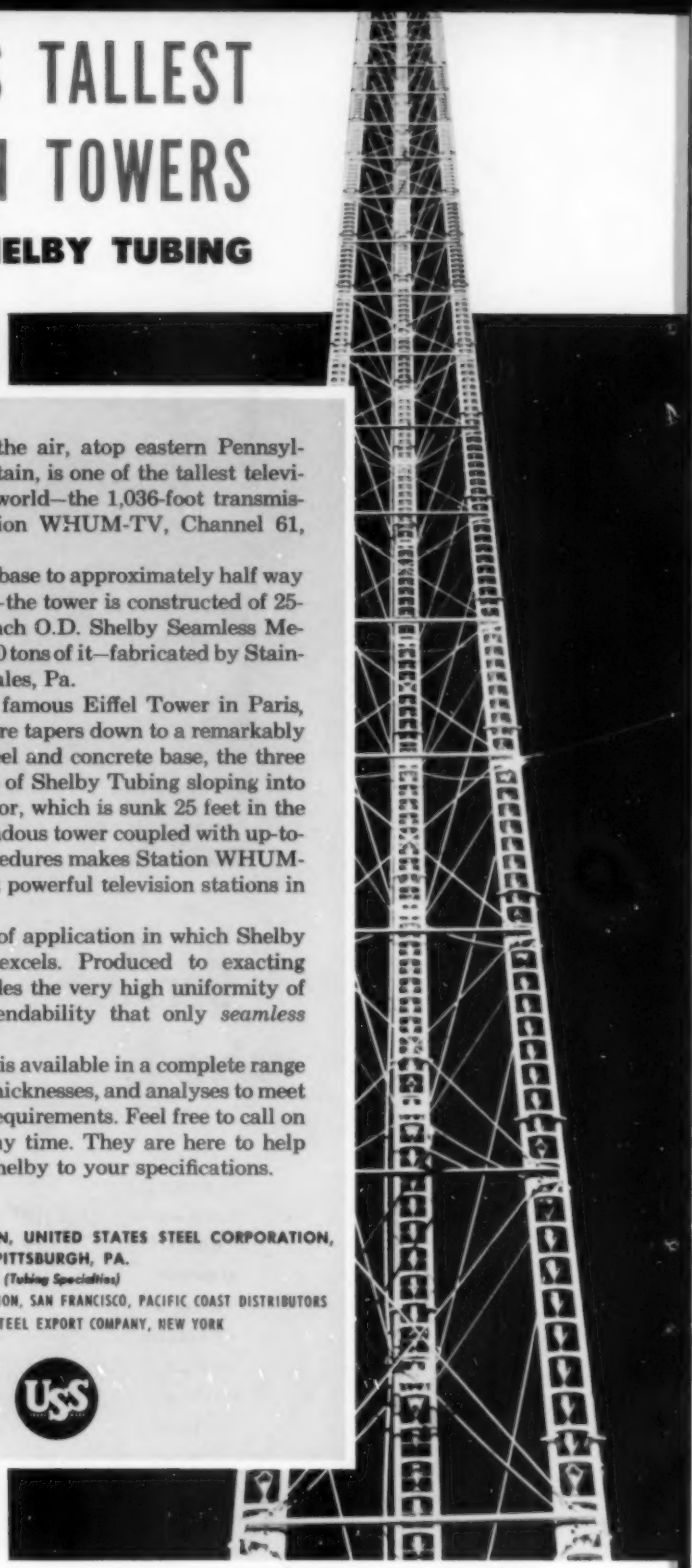
UNITED STATES STEEL

ONE OF THE WORLD'S TALLEST TELEVISION TOWERS

RESTS ON 50 TONS OF SHELBY TUBING





• Rising high in the air, atop eastern Pennsylvania's Blue Mountain, is one of the tallest television towers in the world—the 1,036-foot transmission tower of Station WHUM-TV, Channel 61, Reading.

From its tapered base to approximately half way up—about 500 feet—the tower is constructed of 25-foot sections of 4-inch O.D. Shelby Seamless Mechanical Tubing—50 tons of it—fabricated by Stainless, Inc., North Wales, Pa.

Higher than the famous Eiffel Tower in Paris, the gigantic structure tapers down to a remarkably small triangular steel and concrete base, the three supporting sections of Shelby Tubing sloping into their concrete anchor, which is sunk 25 feet in the ground. The tremendous tower coupled with up-to-date television procedures makes Station WHUM-TV one of the most powerful television stations in the world.

This is the type of application in which Shelby Seamless Tubing excels. Produced to exacting standards, it provides the very high uniformity of strength, and dependability that only *seamless* tubing can give.

Shelby Seamless is available in a complete range of diameters, wall thicknesses, and analyses to meet the most exacting requirements. Feel free to call on our engineers at any time. They are here to help you apply U·S·S Shelby to your specifications.

NATIONAL TUBE DIVISION, UNITED STATES STEEL CORPORATION, PITTSBURGH, PA.
(Tubing Specialties)
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS

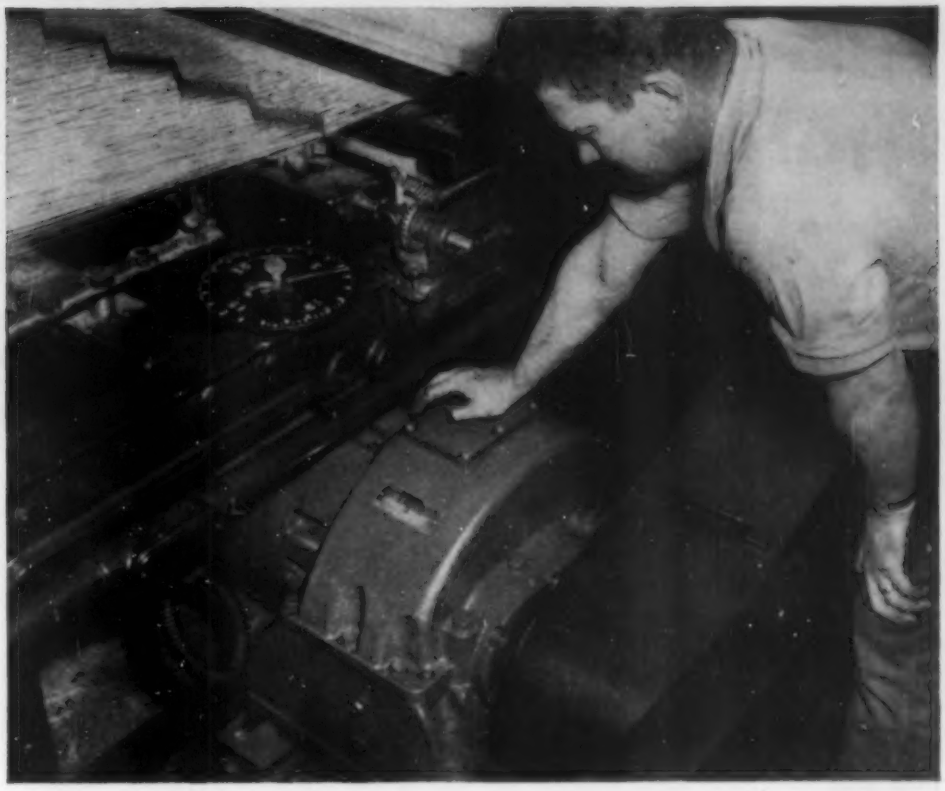
WALLS WITHOUT WELDS

THE TOWER WAS ERECTED in 25-foot sections—each section alternately painted red and white. In an average 8-hour work day, the crew completed ten sections.

TRANSMISSION TOWER, Station WHUM-TV Reading. Steel guy wires, 1¼ inch dia., are attached to the tower at consecutive 175-foot levels, and are anchored in concrete 400 feet and 800 feet from the structure in all directions. Aircraft warning lights are also located at 175-foot levels.

U S S SHELBY SEAMLESS MECHANICAL TUBING

UNITED STATES STEEL



The Dana Warp Mills took advantage of Life-Line Gearmotors' compactness and operating efficiency. Shown is a Life-Line Gearmotor driving a delivery roll on a slasher.

Close-Quarter Servicing No Problem when your drive is a Westinghouse Gearmotor

Powering equipment at the Dana Warp Mills meant putting compact and dependable drive units into cramped quarters. To meet space limitations, designers carefully selected gearmotors with minimum size and definite servicing advantages . . . they specified Life-Line Gearmotors.

Integral design of Life-Line Gearmotors provides maximum saving in space and means no intricate coupling or alignment problems.

Inspection and servicing of Life-Line Gearmotors is simple. Sight gauges on both sides of gear case enable quick detection of oil level. The gear case is split horizontally and by removing a few bolts, the gear cover can be lifted clear of the unit. This simple operation makes all working parts accessible without draining oil or disturbing the unit mounting. Machine alignment remains true.

Life-Line* motor features and tough, precision-made Westinghouse gears combine to give Life-Line Gearmotors lasting stamina, even on the most rugged jobs.

For detailed information, write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-07323

*Trade-Mark

YOU CAN BE SURE... IF IT'S Westinghouse

Here's what you get in HOUGHTON VIX-SYN Packings

LONG SERVICE LIFE—Houghton's VIX-SYN synthetic rubber packings are compounded to eliminate swelling or shrinkage under use with all common types of hydraulic oils and fluids. Their unique molding process assures a compact, close-grained structure.

SMOOTH, PERFECT SEALING SURFACE—VIX-SYN packings are molded in polished molds. This assures a mirror-smooth surface that reduces wear and friction in moving seals.

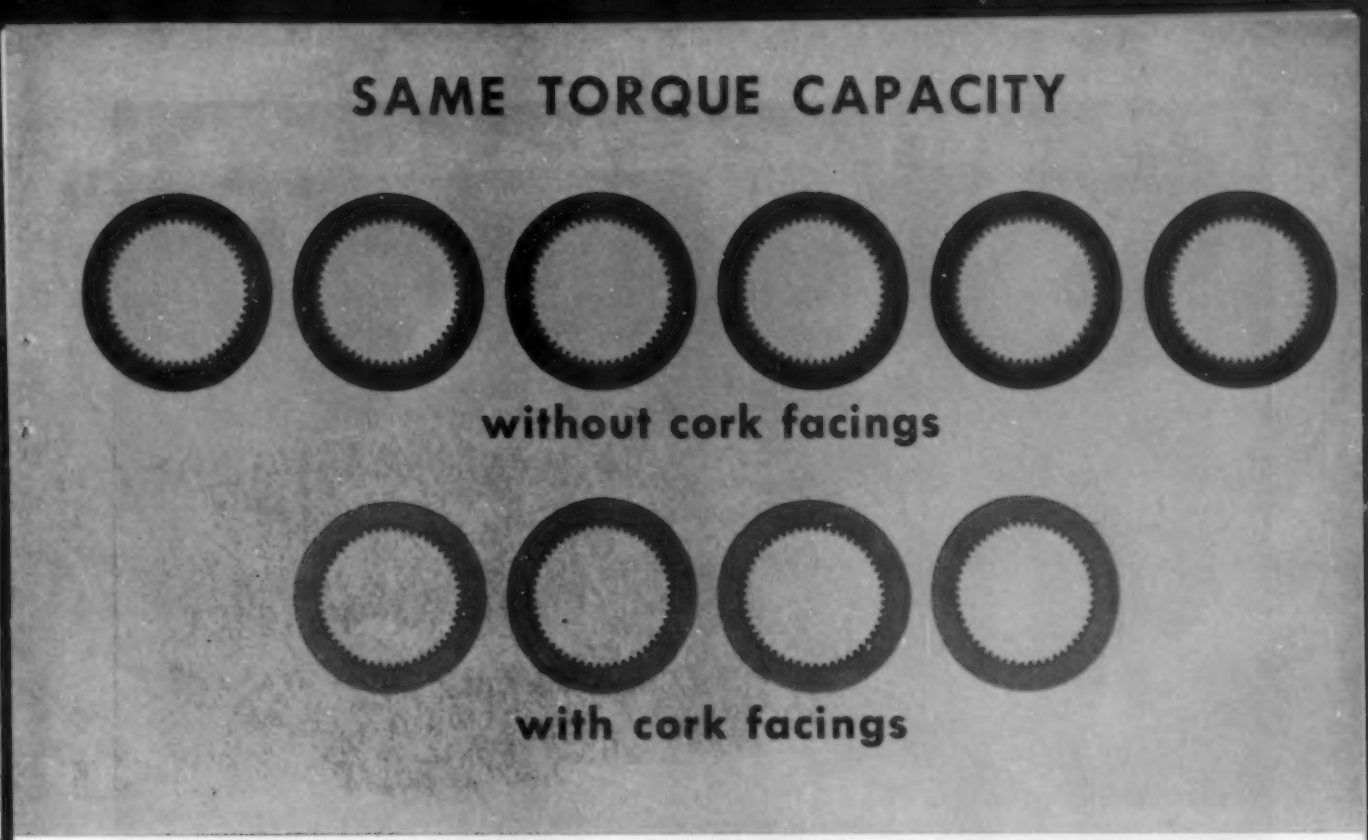
FAST, DEPENDABLE DELIVERY—Adequate stocks of all popular sizes of VIX-SYN "O" rings, "V" Packings and "U" Cups are maintained. And these stocks are backed up by large, modern production facilities that insure delivery of *your* packings to meet *your* production schedules.

Give your hydraulic or pneumatic equipment the advantages of Houghton VIX-SYN Packings. We'll be glad to quote on your requirements on *your* delivery schedule. Write E. F. Houghton & Co., 303 W. Lehigh Ave., Phila. 33, Pa.

VIX-SYN PACKINGS
. . . products of

E. F. HOUGHTON & CO.
PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .



COMPARISON SHOWS how cork facings help you save money on clutch costs. Conventional transmission has six plates (top), twelve facings. Same transmission redesigned for cork facings needs only four plates, eight facings, is smaller and lighter, less costly to make.

Cork clutch facings:

High torque capacity at low cost

Cork-compounded clutch facings retain a higher coefficient of friction when immersed in oil than other known friction materials. They transmit power smoothly at engagement pressures up to 150-200 psi, depending on conditions, and with ambient oil temperatures above 300° F.

Cork's high torque capacity points the way to important savings for users of cork facings. Cork transmits a given amount of torque with fewer or smaller plates, or lower engagement pressures. This permits substantial savings through smaller hydraulic systems, lighter weight, or less space.

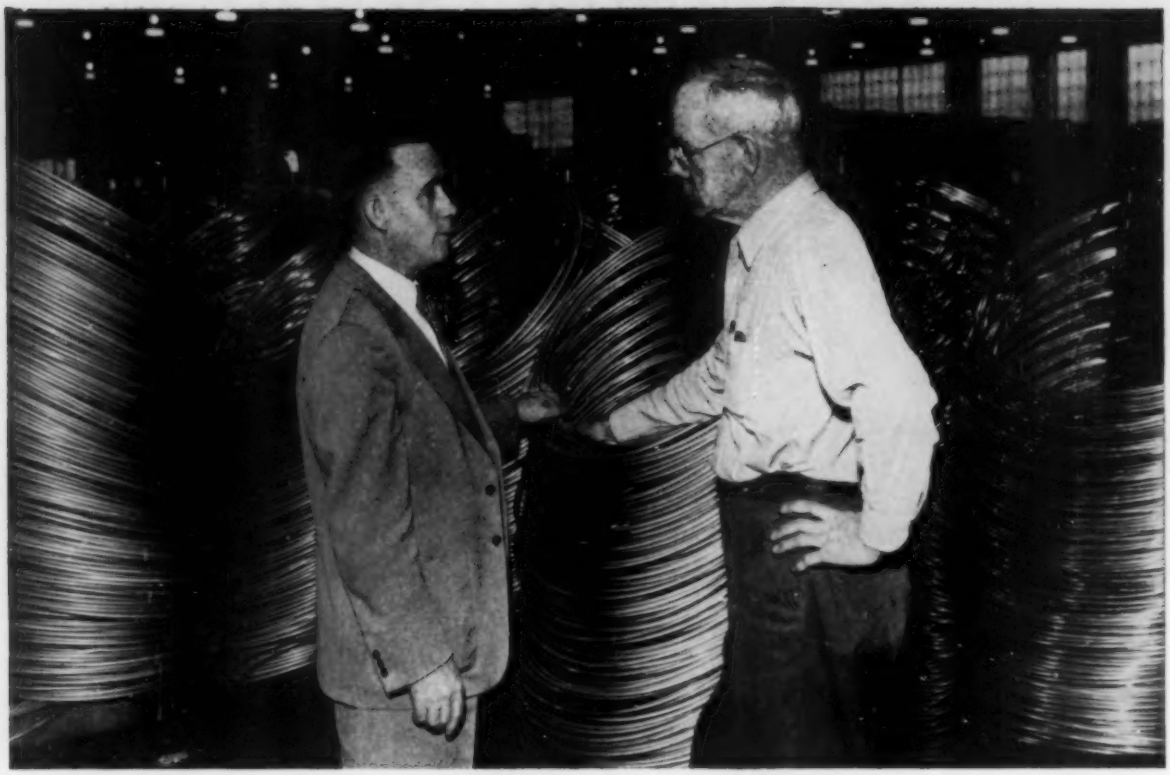
You also save the cost of surface or finish grinding. Cork facings are resilient and mate with their opposing plates perfectly. Cork's relatively low price helps reduce costs, too.

One of the most surprising things about cork facings is their long life. For example, an Armstrong cork-and-rubber facing in an automotive clutch, inspected after 100,000 miles, still showed clearly the original factory tool marks. After 250,000 miles, this same clutch facing was only slightly worn and still in good serviceable condition.

Long before automatic clutches were introduced in automobiles, Armstrong was developing and improving cork-compounded facings. Armstrong's Clutch Facing Test Service is helping many makers of automobiles, appliances, business machines, and industrial machines select facings with a minimum of time and trouble. Armstrong compounds available include a wide variety of cork composition, cork-and-rubber, and cork-fiber materials.

For full information on cork-compounded friction materials, or for specific counsel on selecting a facing for a new clutch design, write us today. Address Armstrong Cork Co., Friction Materials Dept., 7204 Irvin Street, Lancaster, Penna.

ARMSTRONG'S FRICTION MATERIALS



There IS a difference in tubing ...Tubemanship IS that difference!

"Tubemanship?

"Well, sir, I've probably got a different slant on Tubemanship than you have. To me, it means skill and experience. After all, I've been with Wolverine for 34 years. And I've learned a lot! I've found how people recognize a good job. Customers, for example, keep coming back and that means steady work for me and the boys.

"Now you probably have a different angle on Tubemanship than I have. You see it from upstairs."

"That's right, Jim. I do see it from 'upstairs'. I know how we're moving ahead in new developments. How we're always ready to investigate new and better ways of doing things. That's how we came up with Wolverine Trufin* and the Spun End Process.† They're exclusive with us and they represent the type of thinking that keeps Wolverine right out in front of the entire tubing industry!

"And then, there's inspection and quality control from ore or steel strip to finished product. I guess you can say that Tubemanship combines a lot of things—skill, experience, research, equipment, quality control and a knowledge of the tube market."

What Does It Mean to You? Tubemanship means satisfaction—knowledge that when you invest in a Wolverine tubular product—of copper, aluminum or electric-welded steel—it will do its job day after day—year after year. Remember: there IS a difference in tubing—and Tubemanship IS that difference!

WOLVERINE TUBE DIVISION of Calumet & Hecla, Inc., 1479 Central Ave., Detroit 9, Michigan.

*REG. U.S. PAT. OFF. †A PATENTED PROCESS RE. 22465

Wolverine Trufin and the Wolverine Spun End Process available in Canada through the Unifin Tube Co., London, Ontario.

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WOLVERINE TUBE DIVISION
OF CALUMET & HECLA, INC.
Manufacturers of Quality-Controlled Tubing

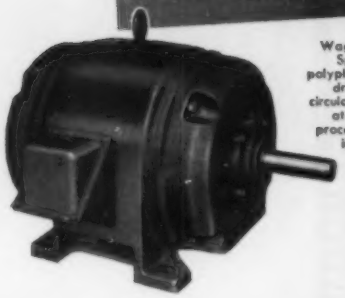
PLANTS IN DETROIT, MICHIGAN, AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES.

Export Dept., 13 E. 40th St., New York 16, N.Y.

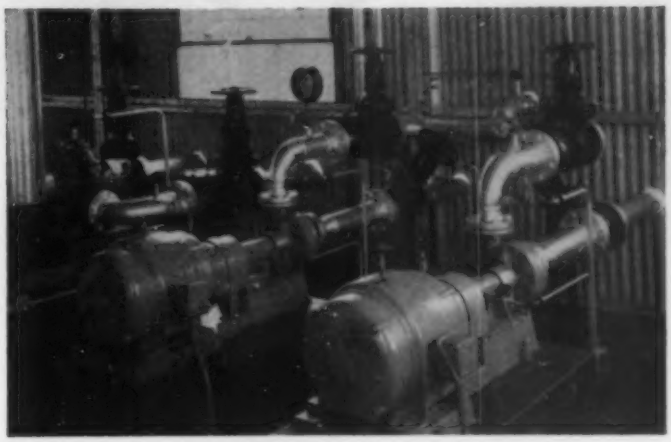
Wagner®
ELECTRIC MOTORS
...the choice of leaders in industry

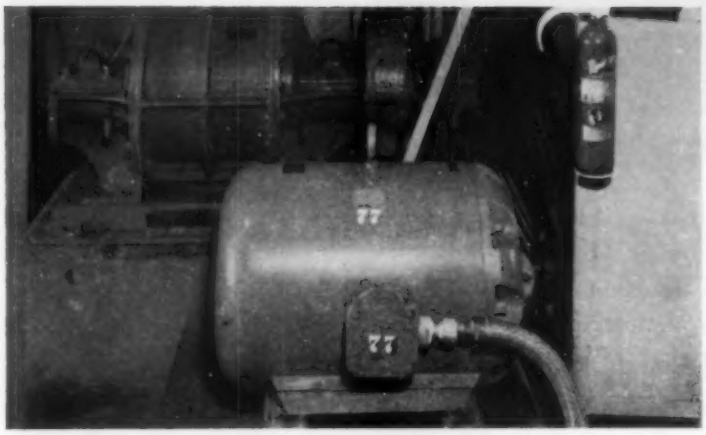
You can *depend* on Wagner Motors to furnish *PLENTY OF POWER* for your product

PUMPS



Wagner 15 hp Splash-proof polyphase motors driving water circulating pumps at a large oil processing plant in Louisiana.





BLOWERS

Wagner 40 hp Explosion-proof motor driving a blower to draw grain into a hopper at a Southern brewery.

Motors that drive compressors, pumps and blowers need plenty of electrical and mechanical stamina to hold up under the hard, steady grind demanded by these applications.

Fitting the right motor to such equipment is not a problem of designing and building special motors, but of choosing a standard Wagner Motor suited to the job. Wagner Motors are diversified in design and can be readily adapted to a wide range of compressor, pump and blower applications.

Improve the performance, economy, and dependability of your product by choosing Wagner Motors as standard equipment.

Bulletin MU-185 gives information on the complete line. Let a skilled Wagner engineer discuss your motor needs with you. Just call the nearest of our 32 branch offices, or write us.

Wagner Electric Corporation EST. WE 1891

WAGNER ELECTRIC CORPORATION
6406 PLYMOUTH AVE., ST. LOUIS 14, MO., U.S.A.

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

ELECTRIC MOTORS
TRANSFORMERS
INDUSTRIAL BRAKES
AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC

M54-6

Which is the CleCap?

. . . the one you got the day you wanted it!

All right, we'll skip the arguments about which of these two cap screws is the best . . . though we can prove that one is better because of the Kaufman *double-extrusion* Process and many other factors.

The BIG DIFFERENCE, if you ask long-time Clecap buyers, is the Clecap organization that cheerfully "breaks its neck" to get you what you want exactly when you want it. An astonishing record over the years!

Why not enjoy the comfortable worryless feeling a lot of buyers get by putting all their cap screw needs up to Clecap?

Cleveland
Top Quality
Fasteners

Ferrous and Non-Ferrous

Hex Head Cap Screws—Bright and High Carbon Heat Treated Steel, Brass, Silicon Bronze, Stainless Steel; ¼" to 2½" dia.
Socket Head Cap and Set Screws—Plain and Knurled: ¼" to 1½" dia. Also Flat and Button Head Styles
Flat Head Cap Screws: ¼" to 1" dia.
Fillister Head: ¼" to 1¼" dia.
Set Screws—Square Head: ¼" to 1½" dia.
Milled Studs: ¼" to 1¼" dia.
Plow Bolts: ½" to 1⅛"
Structural Bolts
Tractor Bolts
Facilities to make larger diameters than listed.
Special Hot and Cold Headed Parts

Ask Your Jobber for Clecap!

The Cleveland Cap Screw Co.
2936 EAST 79TH STREET • CLEVELAND 4, OHIO
VUlcan 3-3700 TWX CV42

WAREHOUSES: CHICAGO • PHILADELPHIA • NEW YORK
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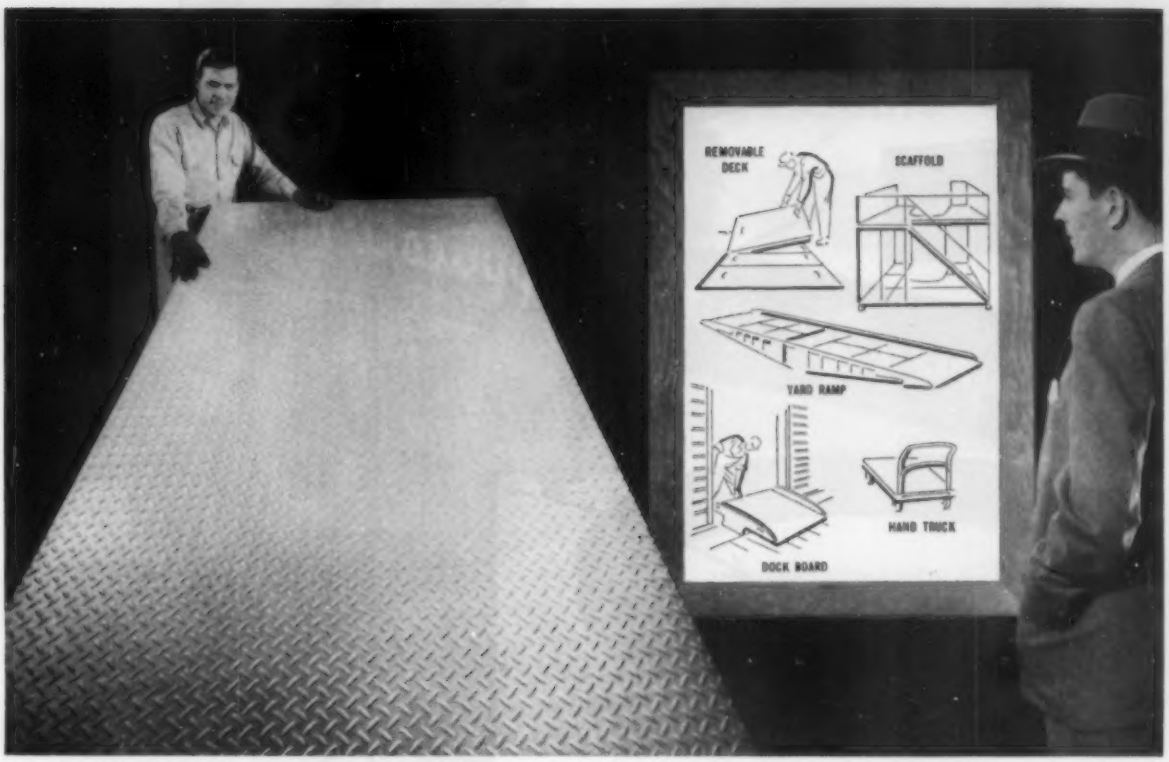
Originators of the Kaufman DOUBLE EXTRUSION Process

DOW



Take a new look at magnesium . . . *wherever equipment must be lifted or moved. Today, more than ever before, magnesium can help you design for greater savings in weight, greater economy in fabricating costs.*

LIGHTWEIGHT MAGNESIUM TREAD PLATE

NOW AVAILABLE IN NEW SIZES AND GAUGES

Now, for the first time in the metals industry, you can get big, new sizes of lightweight Dow magnesium tread plate.

For example, Dow magnesium tread plate made to the famous "Inland" 4-way design is available in lengths up to 16 feet . . . in widths up to 6 feet . . . in thicknesses up to 2 inches. This is important news for every designer.

These larger sizes mean faster, more economical fabrication *plus* new design opportunities in the field of materials handling. Look to magnesium wherever weight and motion are important use factors.

There is a place for tread plate made of magnesium, *the world's lightest structural metal*, almost everywhere, in every plant, every industry.

For further information about Dow magnesium tread plate, fill in the coupon below and mail it today. THE DOW CHEMICAL COMPANY, Midland, Michigan.

Send for new booklet about DOW MAGNESIUM TREAD PLATE

Contains new design opportunities using this *lightest* of all structural metals.

THE DOW CHEMICAL COMPANY, Dept. MA321C, Midland, Michigan

Name_____

Company_____

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you can depend on DOW MAGNESIUM DOW

J-M Uneepac automatic ring packing installed in Polished Rod Lubricator-Stuffing Box manufactured by Muskogee IronWorks, Inc., Muskogee, Okla.

Equipment designers of Muskogee Iron Works report:

"Greatly increased packing life... Uneepac guards against pressure damage"

FOR THEIR NEW LUBRICATOR-STUFFING BOXES, design engineers of Muskogee Iron Works needed a packing with long service life as well as foolproof operation. Uneepac, the Johns-Manville automatic ring packing, fully met both of these requirements and contributed to the success and acceptance which the equipment has encountered.

In this application, Uneepac protects itself against damage by excessive gland pressure. The lips of each ring are guarded by the projecting portion of the Uneepac Center section. As a result, far greater service life and reliability is obtainable in this application than with other types of packings.

Uneepac offers many other important advantages for use in pump rods and plungers, compressors and similar equipment. Seals effectively in a minimum of space. Operates with minimum friction. Has excellent pressure sensitivity. Uneepac provides trouble-free operation because each ring positions itself diametrically as well as vertically. Header or follower rings are not always required because each Uneepac ring is a complete, self-protected unit.

To learn how Uneepac may aid your new equipment design, too, write for booklet PK-58A. Just address Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay St., Toronto 1, Ontario.

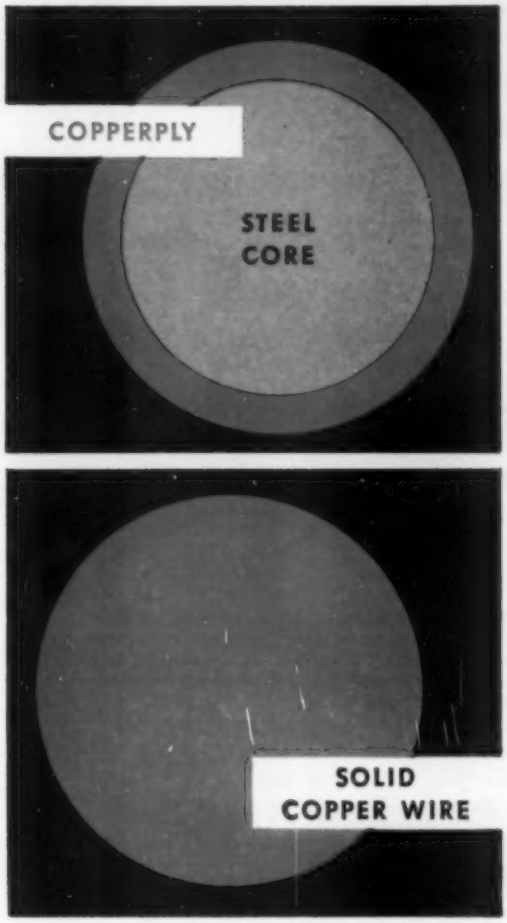
JM PRODUCT

Johns-Manville PACKINGS & GASKETS

cost-cutting
stronger
more dependable

Now available..COPPERPLY®

A NEW COPPER-PLATED STEEL WIRE
OF UNMATCHED NATIONAL-STANDARD QUALITY



COPPERPLY, accurately concentric and uniform, is steel wire electroplated with copper to the thickness required. This type wire was originally used for television lead-in installations. Now this unique wire is solving cost problems in many new applications.

Maybe COPPERPLY gives you ideas for applications in your field . . . uses that will result in substantial savings over solid copper wire.

In addition to cutting costs, COPPERPLY obviously is much stronger than copper wire. And National-Standard makes it with a regular or high tensile steel wire core to fill your specific requirements.

We'll "loan" you an engineer to help you develop any ideas for using COPPERPLY you'd like to explore. It's company policy to give the best service in the industry, in addition to the highest quality special wire and steel products available. Write the National-Standard Company, Niles, Michigan, concerning COPPERPLY. Write the appropriate division listed below on other products.

DIVISIONS OF
NATIONAL-STANDARD

NATIONAL-STANDARD Company
NILES, MICHIGAN

Athenia Steel, Clifton, N. J.
Flat, High Carbon, Cold Rolled Spring Steel

National-Standard, Niles, Mich.
Tire Wire, Stainless, Fabricated Braids and Tape

Reynolds Wire, Dixon, Illinois
Industrial Wire Cloth

Wagner Litho Machinery, Jersey City, N.J.
Metal Decorating Equipment

Worcester Wire Works, Worcester, Mass.
Round and Shaped Steel Wire, Small Sizes

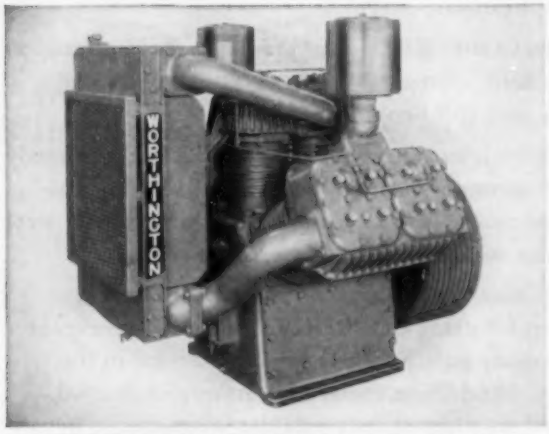
COMPRESSED AIR...
do you get it economically?

FOR SMALLER QUANTITIES of compressed air, Worthington's Balanced Angle Compressor is your best bet. Mills, machine shops and laundries all over praise the quietness and efficiency of this dependable unit. Sizes range from ½ through 15 hp.

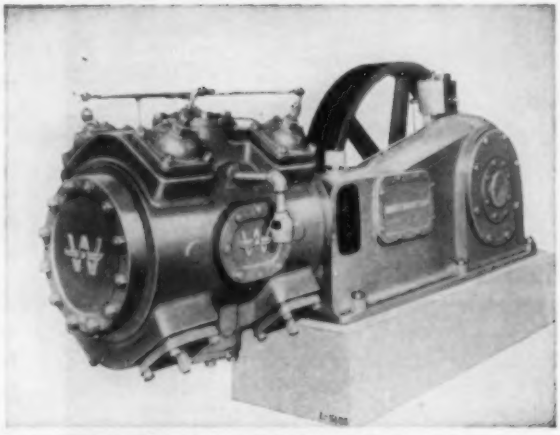
If you can't answer this one, you might find some investigation worthwhile.

When is a compressor worn out? What model and horsepower is the best answer for your application? How much reserve capacity should you allow for?

Providing the answers to these and other questions about air compression is all in the day's work for Worthington. We've got the widest line to choose from, so you'll know any new Worthington equipment you get is "right" for your particular job.



COMPACTNESS AND EASY INSTALLATION are the big advantages of Worthington Radial Air Compressors, used where larger quantities of air are needed. Like all Worthington compressors, the radial is equipped with our exclusive Feather* Valve. Sizes from 25 to 100 hp.



FOR THE REALLY BIG JOBS, specify the horizontal, water-cooled HB—the work horse of the Worthington compressor line. We've had reports about 30-year-old HB's that are giving the same good service as when first installed. Sizes from 7½ on up to 125 hp.

*Reg. U. S. Pat. Off.

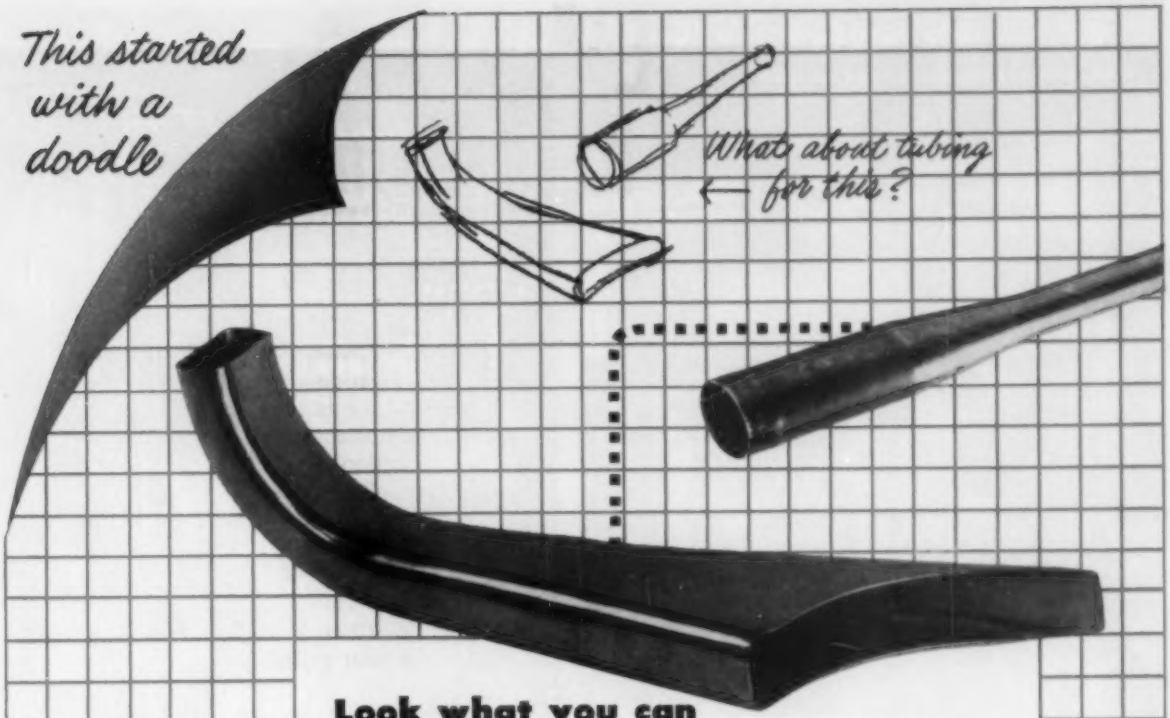
Get the whole story about these modern compressors. Write for Bulletin WP-1099-B52 to Worthington Corporation, Pump and Compressor Merchandising Division, Harrison, New Jersey.

WORTHINGTON

PC.3.14

SPECIFY THESE WORTHINGTON STANDARD PRODUCTS ON YOUR EQUIPMENT

Compressors • Pumps • Multi-V-Drives • Variable Speed Drives



Look what you can do with Stainless Steel Tubing

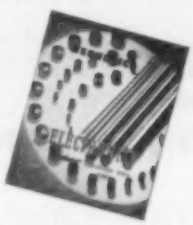
Ever try to make a tapered, rectangular tube with a bend in it? That was the problem recently when an order was received for a stainless steel spout for a cream separator.

Of course, you can cut out a blank, form it, bend it and weld it. That's the hard way. Too many expensive operations.

It is done by starting with a length of Republic ELECTRUNITE Stainless Steel Tubing. Using an exclusive Republic process, the round tube is configured to the tapered shape shown above. This process controls the wall thickness, keeping it uniform, and makes possible a smooth, wrinkle-free bend.

The tube is shaped on special equipment, cut and polished. The result: a cream separator spout with a smooth surface free from contaminating imperfections . . . and at a reasonable production cost.

Does this give you an idea? Perhaps your product would be cheaper to produce. Or give better service. Or open up new markets if it were made from stainless steel tubing or pipe. Republic engineers will be glad to help you design with ELECTRUNITE Stainless Steel Tubing. Ask your Republic Salesman to make the arrangements.



Write for your copy of this informative booklet. It contains extensive data on how to design with ELECTRUNITE Stainless Steel Pipe and Tubing.

REPUBLIC STEEL CORPORATION
Steel and Tubes Division
222 East 131st Street, Cleveland 8, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, New York

REPUBLIC ELECTRUNITE TUBING

REPUBLIC STEEL

Trabon's METERFLO OIL CIRCULATING SYSTEM *ELIMINATES TROUBLE*

ON 20-TON WELDING PRESS

This is one of an installation of 36 four-point welding presses in a large automotive plant, all automatically lubricated by **TRABON METERFLO** systems.

TRABON *positive* lubrication assures all of the 68 bearing points on each press the right amount of filtered oil at the right time. Remote indicating gauges are mounted in the left-hand corner column of the presses for easy visibility. Warning lights flash on in the event of interrupted flow of oil to the bearings.

This installation is typical of the thousands of **TRABON** automatic lubrication systems in operation in industry everywhere . . . under all manner of operating conditions, indoors or outdoors, underground or on the surface.

Trabon ENGINEERING CORPORATION
1814 E. 40th STREET • CLEVELAND 3, OHIO
Oil and Grease Systems

The answer to most of your questions about stainless steels are right at your finger tips, when you use Crucible's unique new Stainless Steel Selector.

Want to know the machinability characteristics of a stainless grade? Resistance to corrosion or scaling? Physical or mechanical properties? You can get the answers to these and other questions simply by setting the arrow on the Selector slide at the proper window. It's just as quick and easy as that.

And almost as fast as you get the answer, you can get the steel you need. For many of the REZISTAL stainless steels shown on the Selector are carried in stock in Crucible warehouses conveniently located throughout the country.

To get your free copy just fill in and mail the coupon. Better do it now.

HOW THE SELECTOR WORKS:

Start with the problem. For example, resistance to corrosion in contact with copper sulfate. Just set the slide at the proper index number shown on the Selector (in this case on the back), and you have the answer in a second -- grades 302 and 316 are fully resistant to this form of attack.

Crucible Steel Company of America
Dept. PE, Henry W. Oliver Building
Pittsburgh, Pa.

Name_____

Company_____ Title_____

Address_____ City_____ State_____

CRUCIBLE first name in special purpose steels

54 years of Fine steelmaking **STAINLESS STEELS**

CRUCIBLE STEEL COMPANY OF AMERICA, GENERAL SALES OFFICES, OLIVER BUILDING, PITTSBURGH, PA.

REX HIGH SPEED • TOOL • REZISTAL STAINLESS • MAX-EL • ALLOY • SPECIAL PURPOSE STEELS

STOW flexible shafting drives this conveyor used to feed ducks. Owned by Mr. Harry Baker of East Port, Long Island.

STOW flexible shafting on the job in AGRICULTURE!

Here are just a few of the many ways STOW Flexible Shafting is being used in agricultural applications. 75 years of experience has given us that all-important know-how you'll find so helpful in working out power transmission and remote control problems on your agricultural equipment.

SHAFTING AVAILABLE IN SIZES 1/8" to 1 5/8"

TRANSMITS UP TO 10 HP at 500 RPM

STANDARD TERMINALS AVAILABLE. special terminals for particular applications

WRITE TODAY FOR FREE AIDS!

Send for FREE Torque Calculator! Gives you the information you need simply, quickly. Eliminates lengthy calculation. Write today, on your company letterhead.

Write today for your free copy of Bulletin 525 containing complete engineering data on STOW flexible shafting.

STOW MANUFACTURING CO.

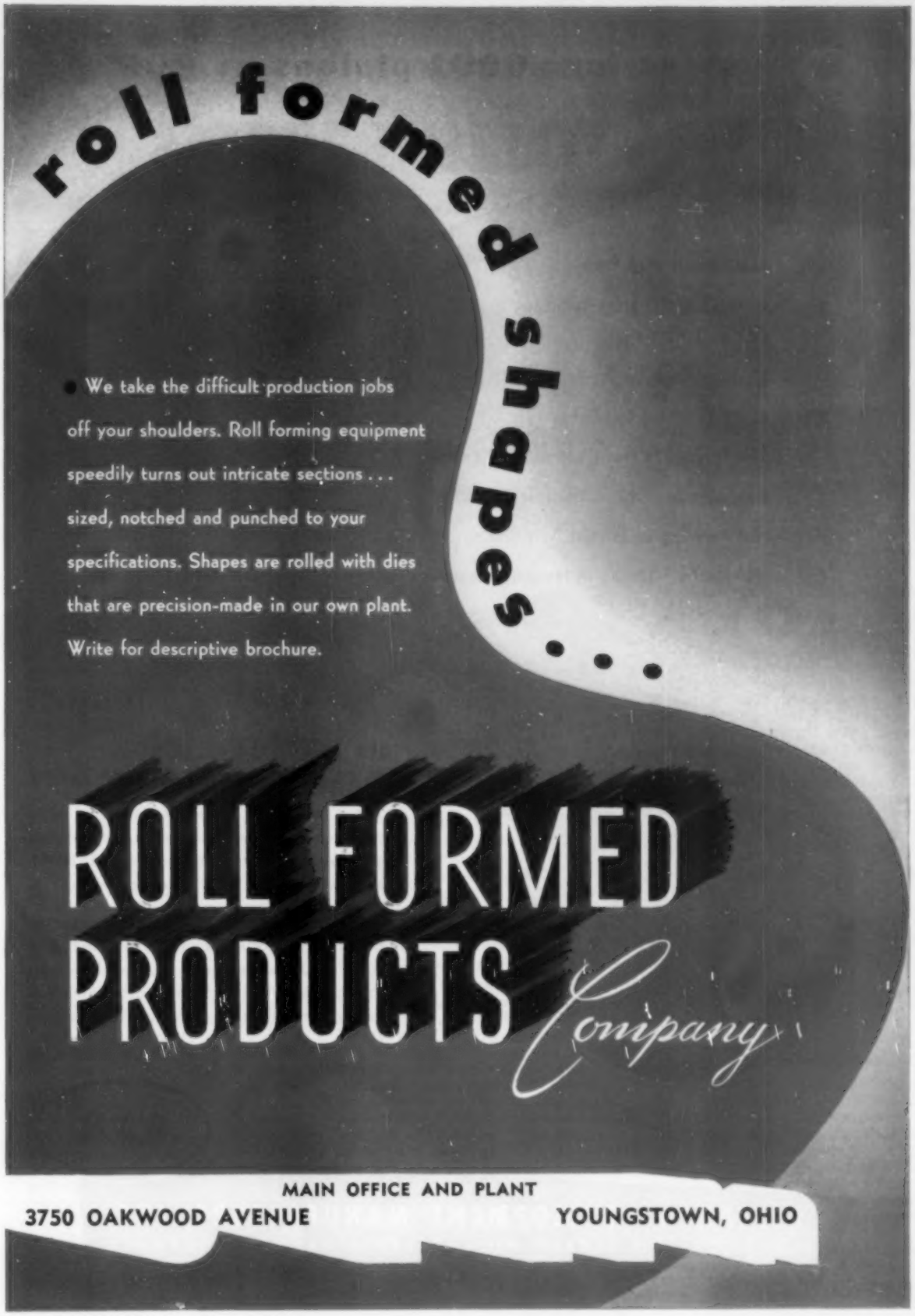
426 State St., Binghamton, N. Y.

STOW flexible shafting powers this Avery Rake, built by the B. F. Avery Division of Minneapolis Moline Company, Louisville, Ky.

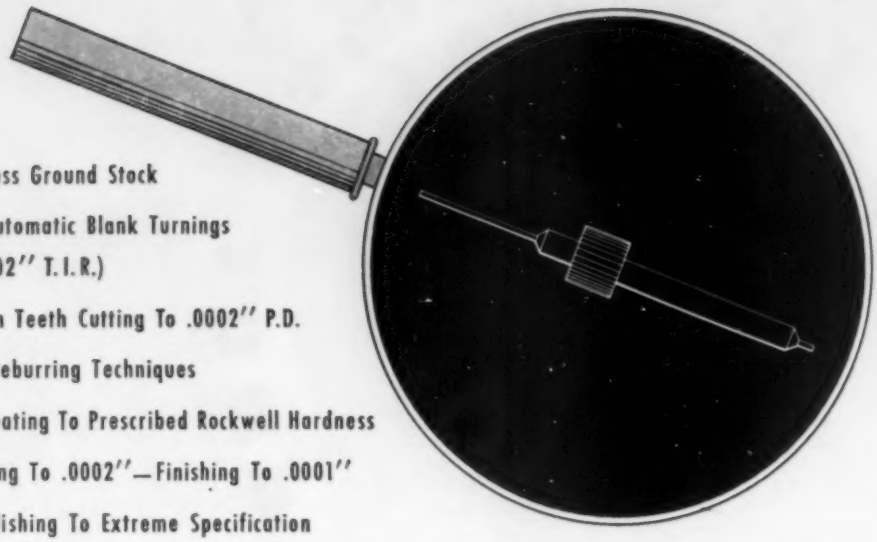
STOW flexible shafting drives the feed conveyor on this G.L.F. bulk feed delivery unit operated by Broome G.L.F. Elevator.

STOW flexible shafting transmits power from the accessory gear box to the pump of the Aero Mist Master, manufactured by Mabry I. Anderson, Mississippi Valley Aircraft Service.

STOW flexible power drive shaft operating telephone pole hole digger. Courtesy of American Telephone and Telegraph Co.


roll formed shapes . . .
• We take the difficult production jobs off your shoulders. Roll forming equipment speedily turns out intricate sections . . . sized, notched and punched to your specifications. Shapes are rolled with dies that are precision-made in our own plant. Write for descriptive brochure.
ROLL FORMED PRODUCTS Company
MAIN OFFICE AND PLANT
3750 OAKWOOD AVENUE
YOUNGSTOWN, OHIO

8 steps for ±.0001 pinions at RDM



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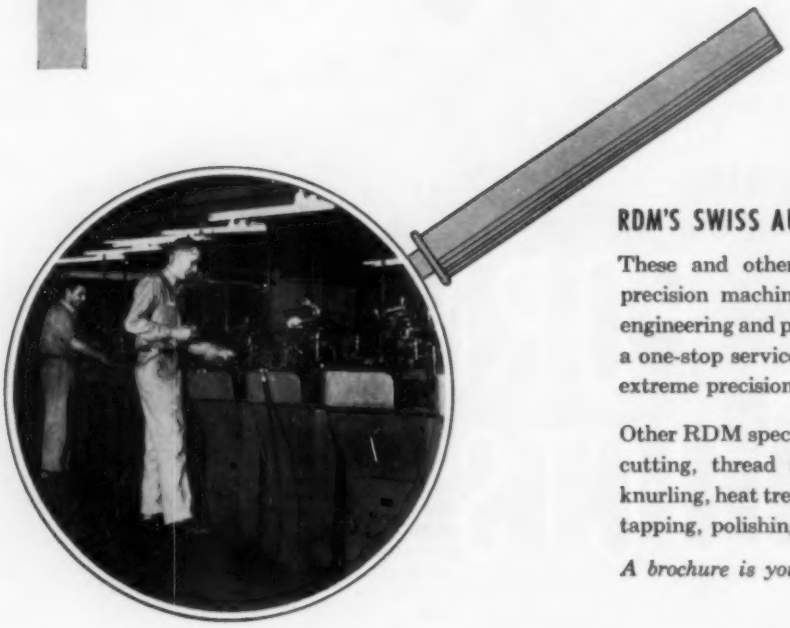
2. Swiss Automatic Blank Turnings (.0002″ T.I.R.)
3. Precision Teeth Cutting To .0002″ P.D.
4. Latest Deburring Techniques
5. Heat Treating To Prescribed Rockwell Hardness
6. Burnishing To .0002″—Finishing To .0001″
7. Leaf Polishing To Extreme Specification
8. Individually Packaged In Protective Capsules



RDM'S SWISS AUTOMATICS IN OPERATION

These and other production lines of high precision machinery, combined with skilled engineering and production staffs, make RDM a one-stop service for difficult components of extreme precision.

Other RDM specialties include fine pitch gear cutting, thread milling and thread rolling, knurling, heat treating, broaching, drilling and tapping, polishing, grinding, milling, plating.

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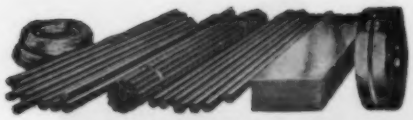


BRIDGEPORT BRASS COMPANY

COPPER ALLOY BULLETIN

Bridgeport Brass Co. MILLS IN BRIDGEPORT, CONN. AND INDIANAPOLIS, IND.—IN CANADA: NORANDA COPPER AND BRASS LIMITED, MONTREAL

Component parts of 5-Star Sprinkler are made from brass, silicon bronze, and phosphor bronze for long, trouble-free service. Courtesy of The Skinner Irrigation Company, Troy, Ohio.

Rainmaking to Order...
A Job for Copper Alloys

The modern way to make fertile acres yield maximum crops is to supply the land with artificial rain—delivering it when and where it is needed and in the proper quantities.

But whether used to meet the vital requirements of field crops, or of lawns, athletic fields, golf courses, and orchards, the sprinklers, valves, couplers and other auxiliary equipment must operate efficiently and reliably under all conditions. They must be strong and tough to take heavy mechanical abuse and must be resistant to corrosive attacks from weather, soil, impurities, and water.

To stand up and deliver long, trouble-free performance in this rugged service, copper-base alloys are the preferred materials. They are universally used for water equipment which covers portable agricultural sprinklers, stationary and pop-up heads for concealed lawn irrigation, or self-closing valves and couplers in hoseless irrigation.

High-Pressure Sprinkler Uses Brass and Bronze

The agricultural sprinkler illustrated above is constructed with practically 100% brass and bronze construction. At 100 lbs. pressure it discharges 400 gallons per minute over an area equal to 2.8 acres.

The body of the sprinkler (3) is a brass casting, as are the main nozzle (4), driving nozzle body (5), impact arm (7), spring housing (15).

The upper bearing which positions the driving nozzle assembly is attached to the body by eight socket-head silicon bronze screws (11). A high-strength, fatigue-resisting alloy is essential at this point in order to bear the brunt of the swinging impact arm which turns the body. Excellent corrosion resistance is an important factor in its selection too, since the screws can easily be removed for periodic cleaning.

Brass for Nozzles and Screws

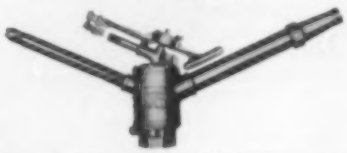
Water entering the body is discharged from three nozzles. The main nozzle arm is made of red brass pipe (1) to which is screwed a cast brass nozzle (4). This delivers an effective, finely broken stream to the outside area. The secondary nozzle arm also made of red brass pipe (2) and a leaded brass nozzle (8) covers the intermediate area. The third nozzle arm (14) is of red brass with a leaded brass nozzle (9) and furnishes the stream which operates the impact arm mechanism, and provides moisture immediately around the sprinkler. Inside nozzle arms (1) and (2) are brass strip rectifiers which minimize turbulent flow of the water.

Nozzles (8 & 9) and slotted driving nozzle body stem (10), as well as the regulating screw, special nut and set screw (12) are made from free-cutting Ledrite brass rod. Bridgeport's Ledrite 6 has a machinability rating of 100 and gives excellent results in screw machine operations.

Phosphor Bronze Controls Rotation

Motivated by a stream of water pushing aside a reversible wedge, the sprinkler circles 360°, step by step. However, the key to the efficiency of the stream coverage lies in the speed of rotation. In the center housing of the impact arm is a spring (6) of Phosphor Bronze Grade A (95% copper and 5% tin), which can be adjusted by increasing or decreasing the tension, thereby controlling the speed of rotation of the sprinkler.

There is also a contact spring (13) which brakes the turning of the sprinkler that is made of phosphor bronze.



5-Star Sprinkler agricultural irrigation systems supply artificial rain in proper quantities when and where it is needed. Courtesy of The Skinner Irrigation Company.

Let Bridgeport Help You

Manufacturers and designers should avail themselves of the Bridgeport laboratory service and the advice of Bridgeport's sales metallurgists in regard to selecting the proper alloy and temper for any specific purpose. Wider use of such alloys as silicon bronze, phosphor bronze and Duronze III (silicon-aluminum bronze) can often improve old products or should be considered when developing new items. Please contact the nearest Bridgeport office for help on your metal requirements. (1363)

HAVE YOUR FASTENING METHODS

kept pace?

It's a long way from the zinc-lined scrub-boxes Great-grandmother knew to today's streamlined home laundry...and design changes come faster than ever these days. That's why it pays to have your fastening methods checked by trained specialists . . . constantly.

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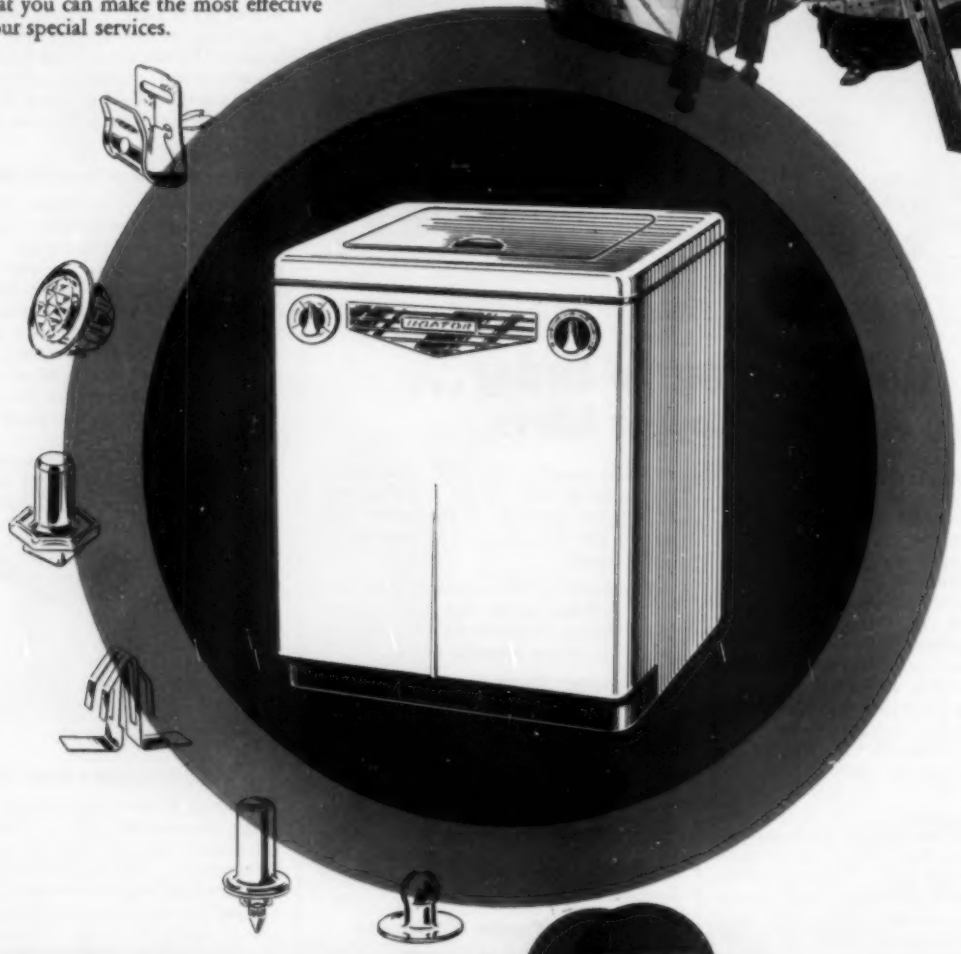
Call your nearest United-Carr field engineer *before* your new designs crystallize. It is in this all-important *planning* stage that you can make the most effective use of our special services.



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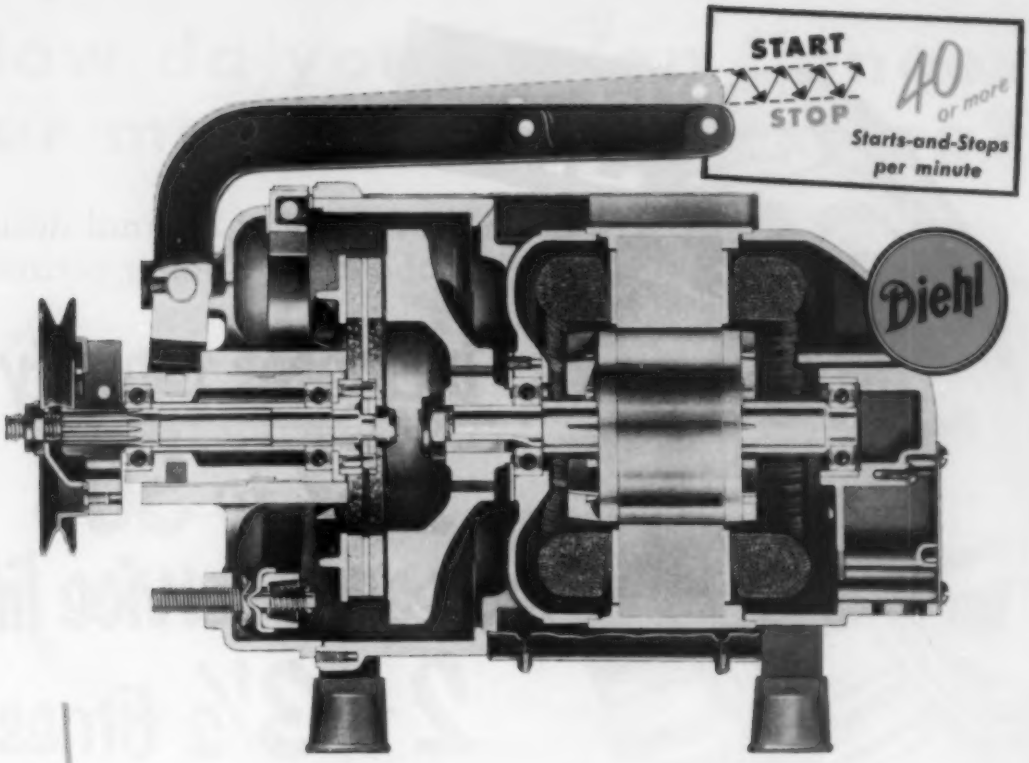
UNITED-CARR FASTENER CORP., CAMBRIDGE 42, MASS.

TAILOR-MADE IN VOLUME QUANTITIES



New DIEHL Type "J" Power Transmitters

Unequalled for Repeated Start-Stop Machine Operation

V-BELT DRIVE PULLEY • HEAVY DUTY CLUTCH • POWERFUL BRAKE
HIGH INERTIA FLYWHEEL • TOTALLY ENCLOSED MOTOR

Repeated, rapid start-stop machine operation, impractical with conventional motor drives, is now obtainable with Diehl Power Transmitters. Forty or more starts and stops per minute, hour after hour, are commonplace with these drives. Many manufacturers have made substantial increases in machine output by the shortening of acceleration and deceleration waiting periods.

In one compact unit, the Diehl Power Transmitter incorporates a totally-enclosed fan-cooled ball bearing motor; a high inertia, dynamically balanced flywheel; a positive short-throw, lever-actuated clutch brake assembly. The actuation may be controlled mechanically or electrically.

These Power Transmitters are now used extensively on machine tools, textile machinery, winding and spooling equipment, conveyors and many other types of machinery where repeated starting and stopping is required. In countless instances, the use of Diehl Power Transmitters has made it possible to simplify machines, reduce costs, improve operation, save space and eliminate over-motoring solely for acceleration. Many of *your* troublesome machine drive problems may be solved with Diehl Power Transmitters.

Available in sizes from ¼ H. P. to 5 H. P.
900, 1200, 1800 and 3600 R. P. M.

DIEHL MANUFACTURING COMPANY
Electrical Division of THE SINGER MANUFACTURING COMPANY
Finderne Plant, SOMERVILLE, N. J.

Please send me the following bulletins
☐ Type "J" Power Transmitter Bulletin No. PE-3303.
☐ Consolidated Motor Catalog and Price List No. PE-3310

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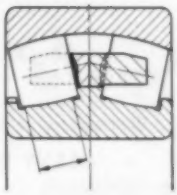
OTHER INTEGRAL AND FRACTIONAL HORSEPOWER MOTORS ARE AVAILABLE IN A WIDE RANGE OF TYPES AND SIZES

the SKF improvement of internal design of spherical roller bearings

Increases capacity 25% to 50%

increases service life 2 to 3½ times

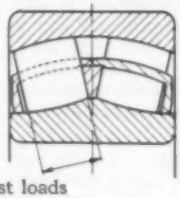


This is the Spherical Roller Bearing design originated by SKF *more than 30 years ago.* The cross-section shows how the integral inner ring flanges, and the undercuts adjacent thereto, limit the effective length of the rollers.

Now, SKF, originator of the Spherical Roller Bearing, has again provided industry with another anti-friction *first.*

This time, it's a revolutionary design advance in Series 222 and 223 bearings providing these advantages:

When designing new equipment, you can obtain the desired life by using smaller or lighter bearings at considerable cost saving. In addition, this forward step in design will carry heavier combinations of radial and thrust loads, or pure thrust loads of greater magnitude. The important self-aligning feature of SKF Spherical Roller Bearings has been preserved, so that considerable misalignment between the shaft and housing has no ill effect whatever on bearing capacity or life.



Here is the latest SKF improvement, a *revolutionary advance in design.* Effective roller guiding is accomplished by means of a separate ring. The need for undercuts is eliminated! This type of guide ring permits the rollers to take the position which their contact with the rings dictates. This assures uniform load distribution over the entire length of the longer rollers at all times. *Result* — greatly increased capacity and life.

During more than 4 years, thousands of installations have been made in railroad journals, vibrating screens, steel mill machinery and numerous other fields. In all cases performance has been outstanding.

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BALL AND ROLLER BEARINGS

This 12-page booklet gives you additional facts — sizes available — added capacity, size by size — increased life you can expect for each size — dimensional tabulations — and load and speed data. Write now for your free copy of Booklet No. 365-2.

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You'll find the answer in this up-to-date gasket manual

17 helpful sections, including:

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When you're designing flanges for a new joint, or when you need a gasket material to meet current SAE-ASTM or government specs, you'll find helpful information in the 24-page booklet, "Armstrong's Gasket Materials." Newly revised for 1954, Armstrong's manual has complete information on gaskets and gasket materials, including valuable and hard-to-find data on gasket, flange, and joint design. Check it in Sweet's product design file or write for your copy. Just send the coupon.

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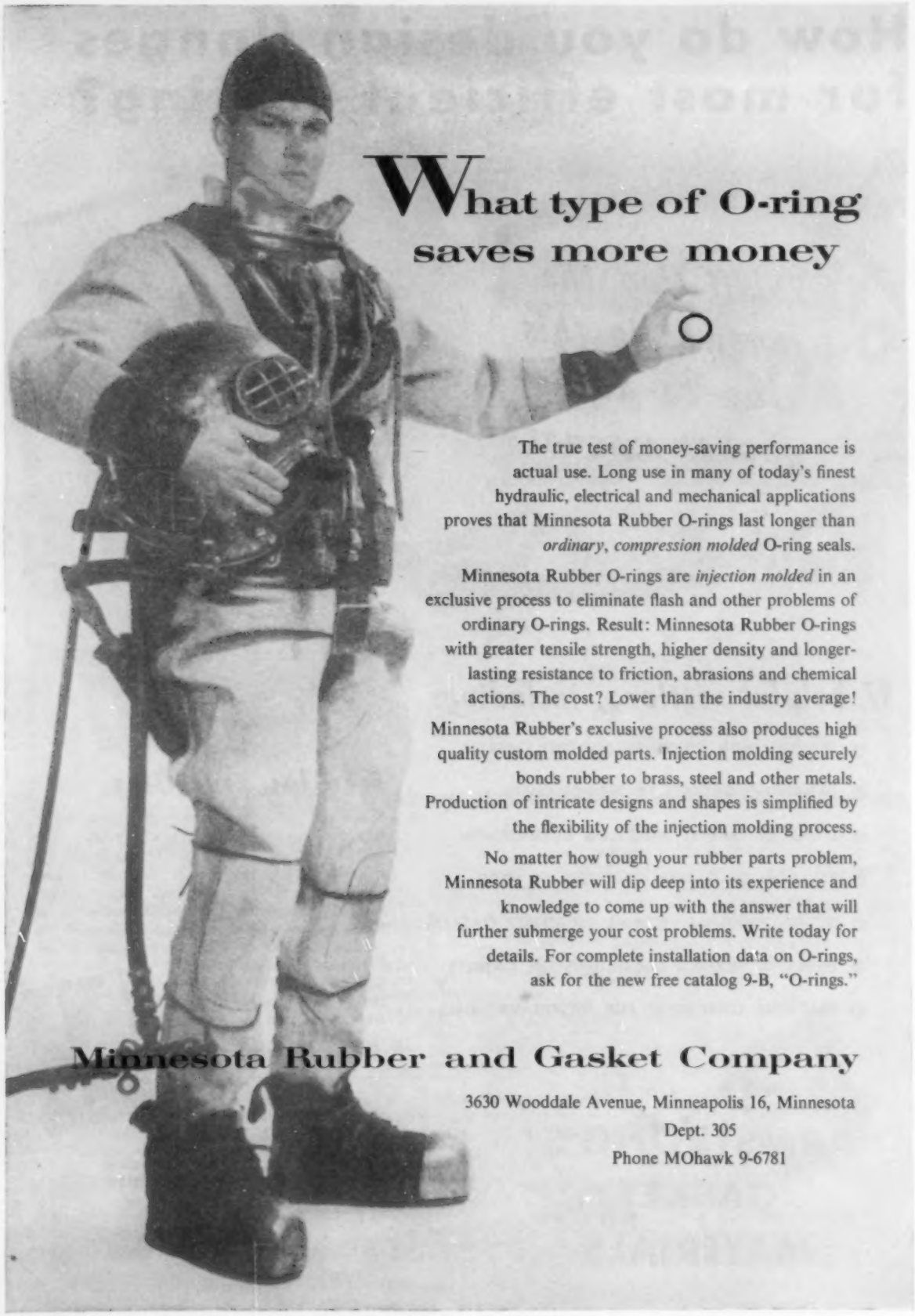

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The true test of money-saving performance is actual use. Long use in many of today's finest hydraulic, electrical and mechanical applications proves that Minnesota Rubber O-rings last longer than *ordinary, compression molded* O-ring seals.

Minnesota Rubber O-rings are *injection molded* in an exclusive process to eliminate flash and other problems of ordinary O-rings. Result: Minnesota Rubber O-rings with greater tensile strength, higher density and longer-lasting resistance to friction, abrasions and chemical actions. The cost? Lower than the industry average!

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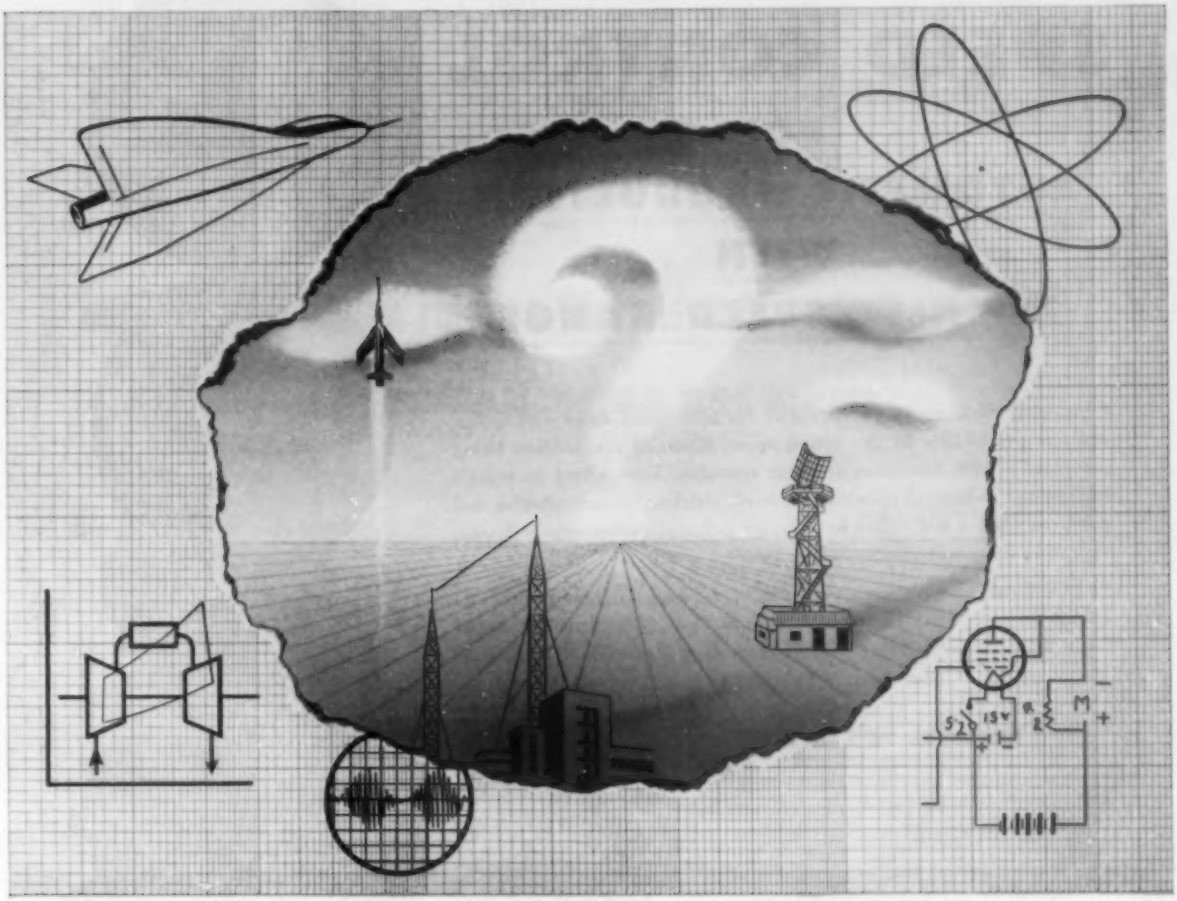

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SPECON can play an important part in stepping up your production efficiency, too. We'll be pleased to show you how. Write to: Speed Control Div., Fairchild Engine & Airplane Corporation, Wickliffe, Ohio.

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- ★ Instant automatic performance provides uniform uninterrupted speed acceleration.
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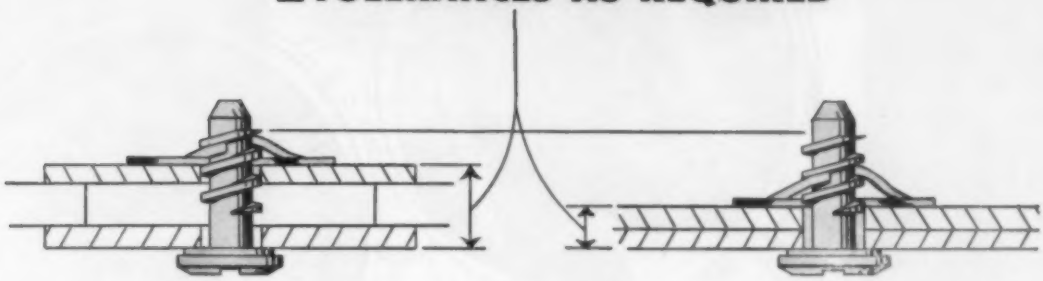
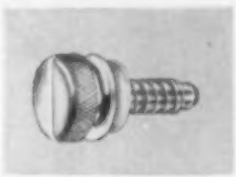
SOUTHCO **quick release fasteners provide:**

±TOLERANCES AS REQUIRED





Industrial tolerances, provided only by Southco Quick-Release Fasteners, are designed to accommodate variations in thickness normally encountered in metal working. No longer is it necessary to call out a different size precision type fastener because of a few thousandths variation. You eliminate a serious stock problem and reduce assembly time when you specify SOUTHCO.

You can easily choose the right Southco Quick-Release Fastener from a wide variety of stock sizes which include two diameters and three head styles.

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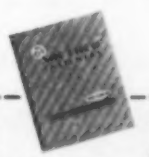

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Please send me, without cost, the 24 page SOUTHCO FASTENER HANDBOOK ☐

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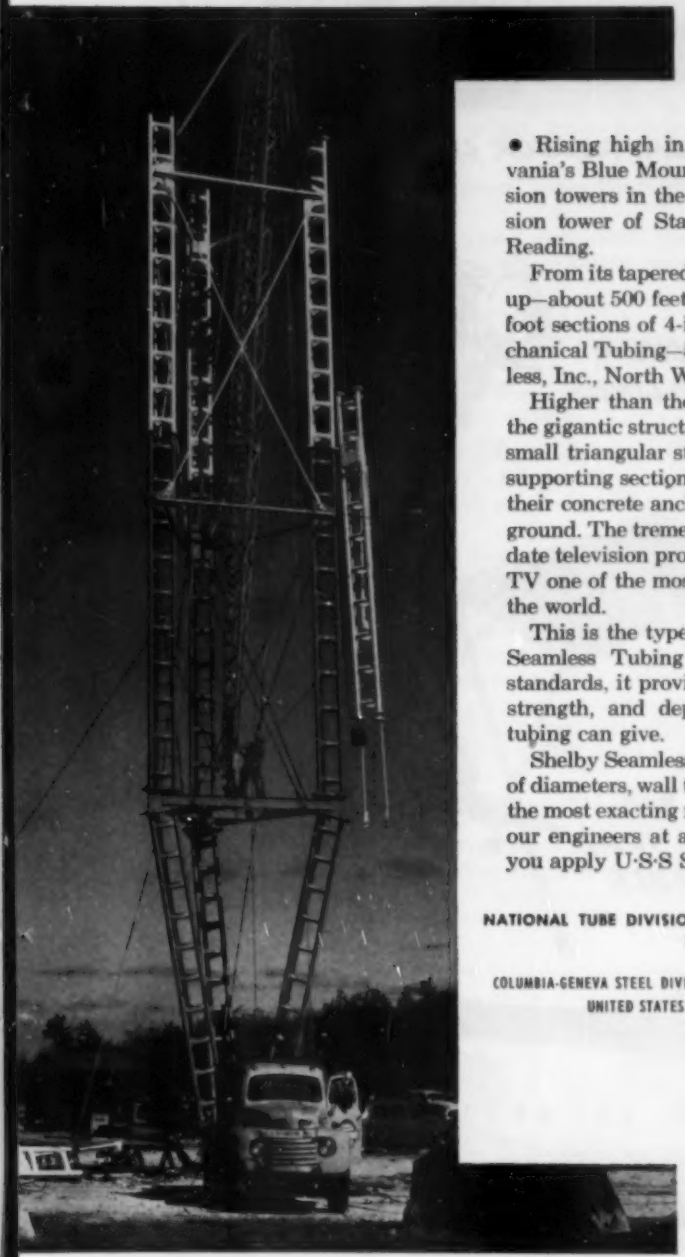
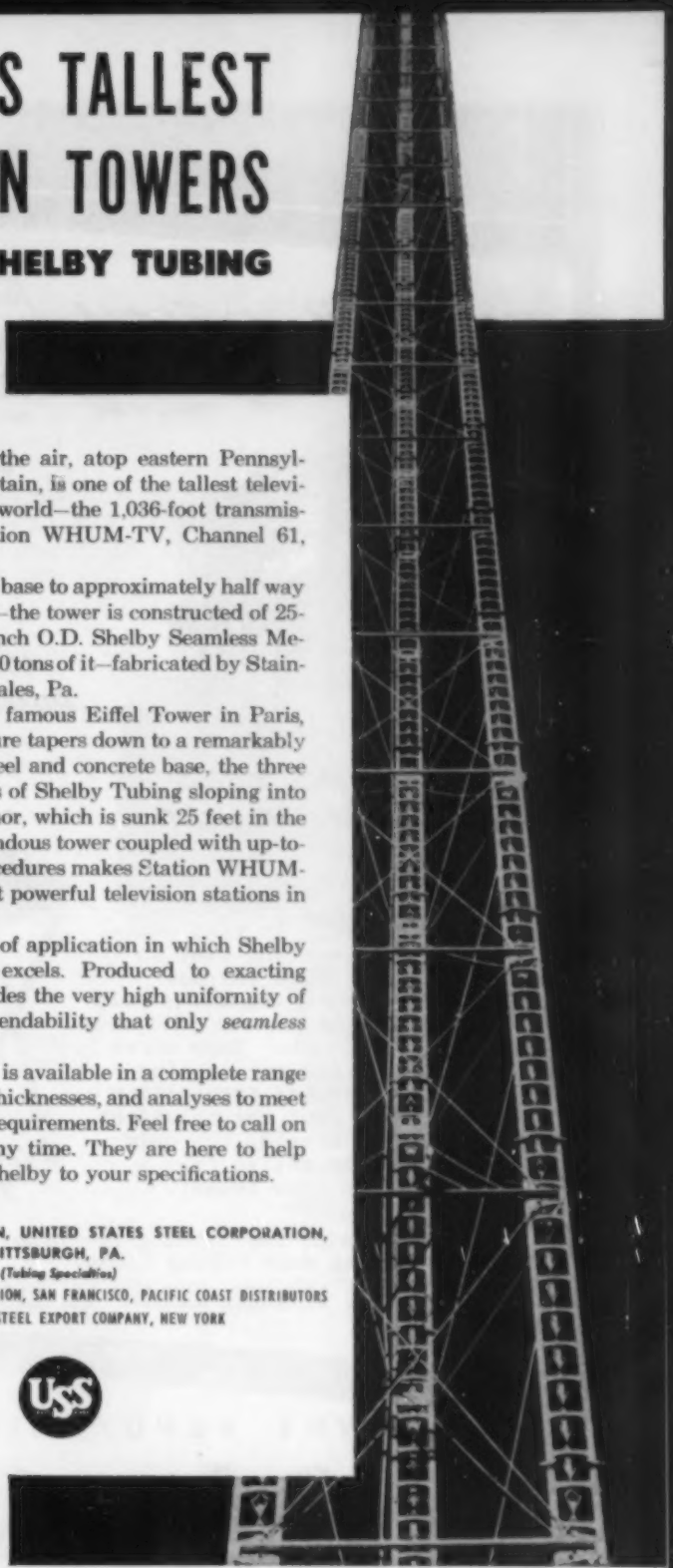
ONE OF THE WORLD'S TALLEST TELEVISION TOWERS

RESTS ON 50 TONS OF SHELBY TUBING





• Rising high in the air, atop eastern Pennsylvania's Blue Mountain, is one of the tallest television towers in the world—the 1,036-foot transmission tower of Station WHUM-TV, Channel 61, Reading.

From its tapered base to approximately half way up—about 500 feet—the tower is constructed of 25-foot sections of 4-inch O.D. Shelby Seamless Mechanical Tubing—50 tons of it—fabricated by Stainless, Inc., North Wales, Pa.

Higher than the famous Eiffel Tower in Paris, the gigantic structure tapers down to a remarkably small triangular steel and concrete base, the three supporting sections of Shelby Tubing sloping into their concrete anchor, which is sunk 25 feet in the ground. The tremendous tower coupled with up-to-date television procedures makes Station WHUM-TV one of the most powerful television stations in the world.

This is the type of application in which Shelby Seamless Tubing excels. Produced to exacting standards, it provides the very high uniformity of strength, and dependability that only *seamless* tubing can give.

Shelby Seamless is available in a complete range of diameters, wall thicknesses, and analyses to meet the most exacting requirements. Feel free to call on our engineers at any time. They are here to help you apply U·S·S Shelby to your specifications.

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USS

WALLS WITHOUT WELDS

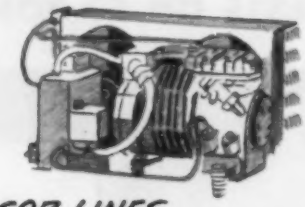
THE TOWER WAS ERECTED in 25-foot sections—each section alternately painted red and white. In an average 8-hour work day, the crew completed ten sections.

TRANSMISSION TOWER, Station WHUM-TV Reading. Steel guy wires, 1¼ inch dia., are attached to the tower at consecutive 175-foot levels, and are anchored in concrete 400 feet and 800 feet from the structure in all directions. Aircraft warning lights are also located at 175-foot levels.

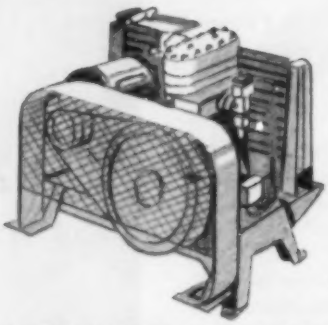
U·S·S SHELBY SEAMLESS MECHANICAL TUBING

UNITED STATES STEEL

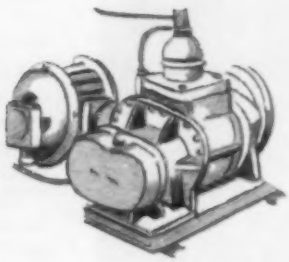
FROM *the Bundy Sketchbook*
TO *jog a designer's imagination*



COMPRESSOR LINES

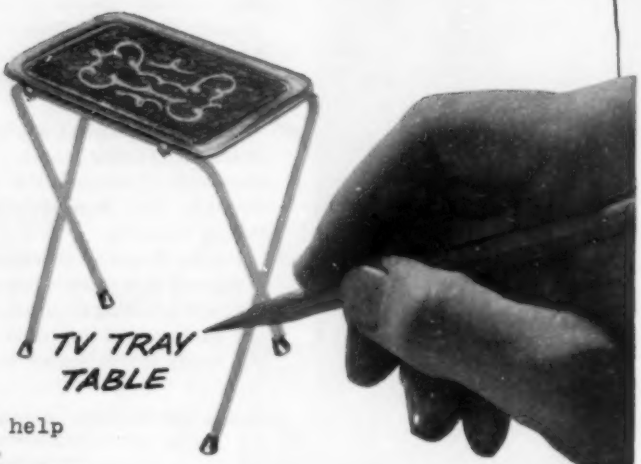


SERPENTINE COILS IN CONDENSER UNIT



VACUUM PUMP LINES

REMARKS Is that cost-saving idea wasting away in a notebook? Then why not let expert Bundy engineers help bridge the gap between idea and finished product. They offer you specialized engineering skills, unmatched fabrication facilities, plus the priceless extra of Bundyweld, the only tubing double-walled from a single strip (see below).



TV TRAY TABLE

WRITE today for catalog for help in developing your tubing ideas.

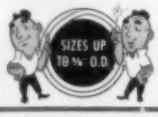
BUNDY TUBING COMPANY, DETROIT 14, MICH.

WHY BUNDYWELD IS BETTER TUBING

Bundyweld starts as a single strip of copper-coated steel. Then it's . .

continuously rolled twice around laterally into a tube of uniform thickness,

and passed through a furnace. Copper coating fuses with steel. Result . . .



Bundyweld, double-walled and brazed through 360° of wall contact.

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DOUBLE-WALLED FROM A SINGLE STRIP

Leakproof	Lightweight
High thermal conductivity	Machines easily
High bursting point	Takes plastic coating
High endurance limit	Takes plating
Extra-strong	Bright and clean
Shock-resistant	No inside bead
Ductile	Uniform I.D., O.D.

Bundy Tubing Distributors and Representatives: ***Bridgeport, Conn.:*** Korhumel Steel & Aluminum Co., 117 E. Washington St. • ***Cambridge 42, Mass.:*** Austin-Hastings Co., Inc., 226 Binney St. ***Chattanooga 2, Tenn.:*** Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • ***Chicago 32, Ill.:*** Lapham-Hickey Co., 3333 W. 47th Place • ***Elizabeth, New Jersey:*** A. B. Murray Co., Inc., Post Office Box 476 • ***Los Angeles 58, Calif.,*** Tubesales, 5400 Alcoa Ave. • ***Philadelphia 3, Penn.:*** Rutan & Co., 1717 Sansom St. • ***San Francisco 10, Calif.:*** Pacific Metals Co., Ltd., 3100 19th St. • ***Seattle 4, Wash.:*** Eagle Metals Co., 4755 First Ave., South • ***Toronto 5, Ontario, Canada:*** Alloy Metal Sales, Ltd., 181 Fleet St., W.

Bundyweld nickel and Monel tubing are sold by distributors of nickel and nickel alloys in principal cities.

NEW
High Density Compressed FIBER·GLASS

To help you soften impact, or absorb vibration

L·O·F announces a new, high-density, fibrous glass material with a wide range of applications. Can be used in sheets or formed to make safety pads, housings and other shapes.

L·O·F High Density Compressed Fiber·Glass offers the following advantages:—

1. Absorbs and reacts to impact more slowly than other materials; affords extremely effective shock protection.
2. Absorbs vibration-borne sound.
3. Excellent thermal insulation in the lower density range.
4. The glass fibers will not burn, mildew, rot, absorb moisture or odors, or support fungi.

High Density Compressed Fiber·Glass is now being used in the following design applications:—

For impact absorption—in automobile safety pads and arm rests.

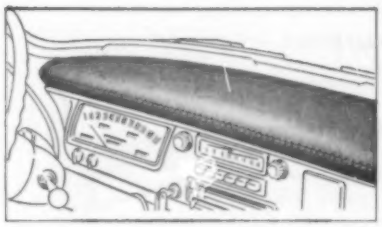
To absorb vibration—to form blower housings and intake deflectors in air conditioners; for automobile roof liner.

For thermal insulation—plus vibration absorption, as a low-cost breaker strip between metal panels.

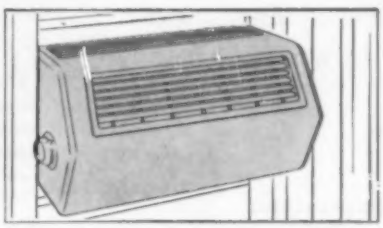
In making High Density Compressed Fiber·Glass, Super·Fine is cured under heat and pressure. Densities vary from 3 lbs. to 50 lbs. per cubic foot. Housings and other shapes can be molded at the Libbey·Owens·Ford plant in Parkersburg, W. Va.

High Density Compressed Fiber·Glass may be just the material you need to solve an impact-, vibration-noise or thermal-insulation problem. For further information, please contact your nearest L·O·F office (offices in 26 major cities). Or write: Libbey·Owens·Ford Glass Company, Fiber·Glass Division, 444 Wayne Building, Toledo 3, Ohio.

Hi, Mr. Designer! How can YOU put me to work?



In this safety pad, molded from High Density Compressed Fiber·Glass, the leading edge (where impact could be expected) is made softer than the rest of the pad.



This blower housing for an air conditioner, made of High Density Compressed Fiber·Glass, absorbs vibrational noises; helps to solve one of the chief problems in air-conditioning design.

High Density Compressed Fiber·Glass is specified as a low-cost breaker strip between panels in prefabricated steel homes, serving as weather seal, thermal insulation and vibration absorber.

*High Density Compressed Fiber·Glass

L·O·F GLASS Corvalux FIBER·GLASS

FIBER · GLASS

LIBBEY·OWENS·FORD GLASS COMPANY
FIBER·GLASS DIVISION

Illustrated is a sample of Purebon's many applications.

NO LUBRICATION NECESSARY with PUREBON

Carbon-Graphite especially designed for mechanical applications.

PROPERTIES of PUREBON

- Molded to size—for many applications
- Self-lubricating (or by material handled)
- Strong and tough
- Readily machinable
- Chemically inert
- Withstands high temperatures
- Non-Toxic

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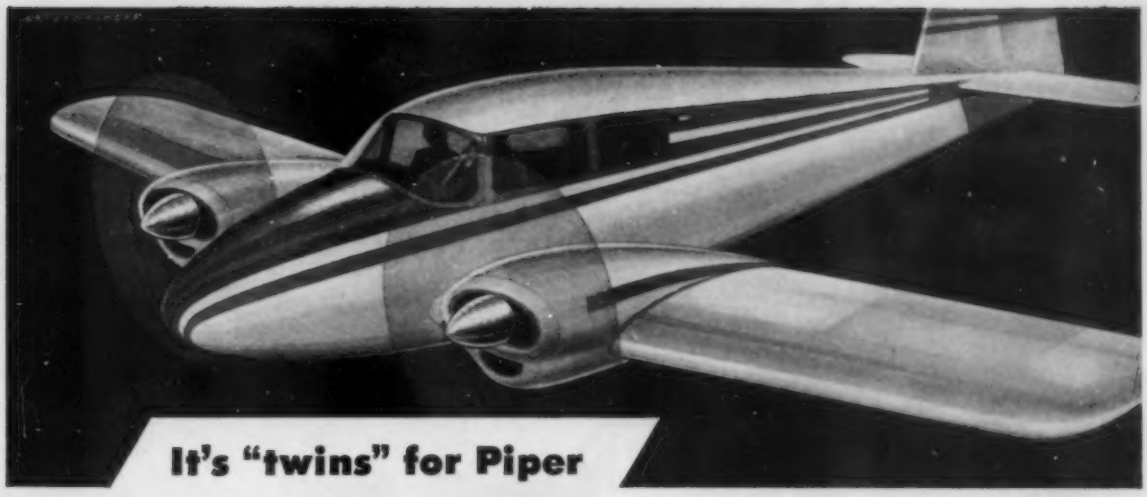
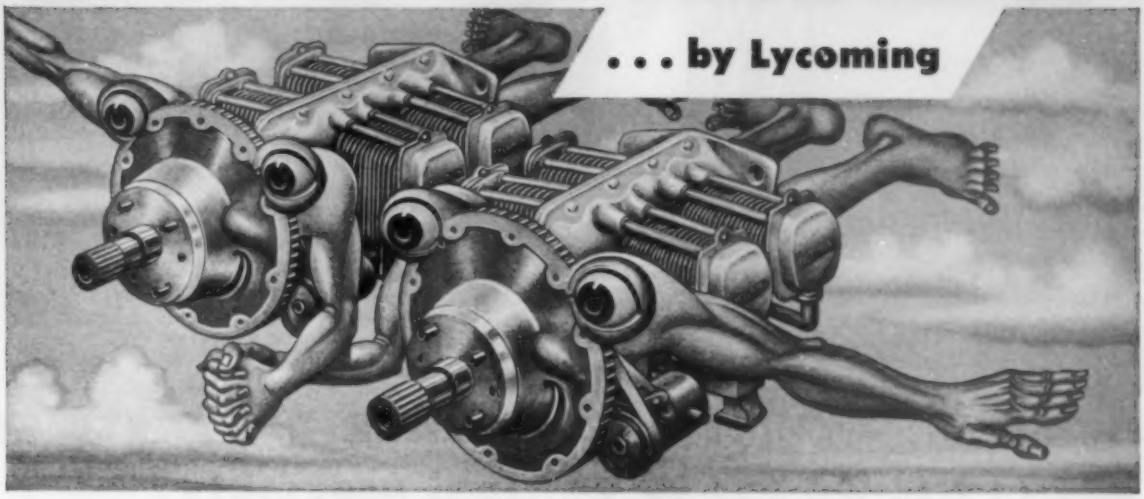
Leaders FOR OVER 40 YEARS IN PURE CARBON PRODUCTS

PURE CARBON COMPANY, INC.

450 HALL AVENUE, ST. MARYS, PENNSYLVANIA



It's "twins" for Piper



. . . by Lycoming

This is the Piper Apache . . . the all-new executive plane that brings new economy to the twin-engine field while maintaining high standards of safety and dependability.

It is powered by two proven Lycoming 150-h.p. air-cooled engines designed especially for the Apache. These power plants provide an improved horsepower-weight ratio, new compactness . . . and are so powerful that the Apache can safely fly and land with a full load *on one engine alone.*

We suggest a test flight in the Piper Apache for a new experience in air travel.

Just off the press! "THE LYCOMING STORY". . . 40 interesting, illustrated pages that give you information about the many Lycoming services listed below. Write for it on your letterhead.

Aircraft Engines
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LOOK TO **Lycoming**

DIVISION OF AVCO MANUFACTURING CORPORATION
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WESTERN ELECTRIC EQUIPMENT

Brings "ANYWHERE" Closer to Home!

Strong, lightweight
REDUCE COSTS

PARKER DIE CASTINGS on final assembly

Wherever you are, on business or pleasure, your home base is only as distant as the nearest telephone. In business, private branch switchboards like the one shown above speed your voice to a waiting ear. To produce complex telephone equipment for the Bell System the Western Electric Co. uses literally thousands of parts. Among the many specialists supplying components is Parker White Metal Company. Parker Die Castings are used in the assembly as illustrated above. Parker Die Castings require no machining or finishing operations, thus reducing costs. They are produced to rigid specifications, of exactly the right alloy . . . strong and lightweight. Parker Die Castings are in use in nearly every industry and our experience is yours for the asking. Consult with Parker on your next die casting requirements.

and when you think of Die Castings
THINK OF

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PARKER ALUMINUM *and* ZINC *Die Castings*

ARROW·HART

ARROW AH HART

Electronic VARIABLE SPEED DRIVE

. . . the "BRAIN" that brings "AUTOMATION" to this new

ROY SCREW SLOTTER

One Machine does all this

- **HANDLES ALL TYPES OF WOOD, SHEET METAL and MACHINE SCREWS**
- **SLOTS ALL HEAD SHAPES in ALL MATERIALS**
- **HANDLES ALL SCREW BLANKS from NO. 2 to NO. 12 and from ¼" to 1½" LONG**
- **ADJUSTS FROM 125 TO 720 PIECES PER MINUTE**

BOTH THE WORK CARRIER WHEEL AND THE SAW HAVE FOUR SEPARATE SPEEDS THAT CAN BE INSTANTLY ADJUSTED INDEPENDENTLY OF EACH OTHER

THANKS TO **ARROW-HART** VARIABLE SPEED DRIVE!

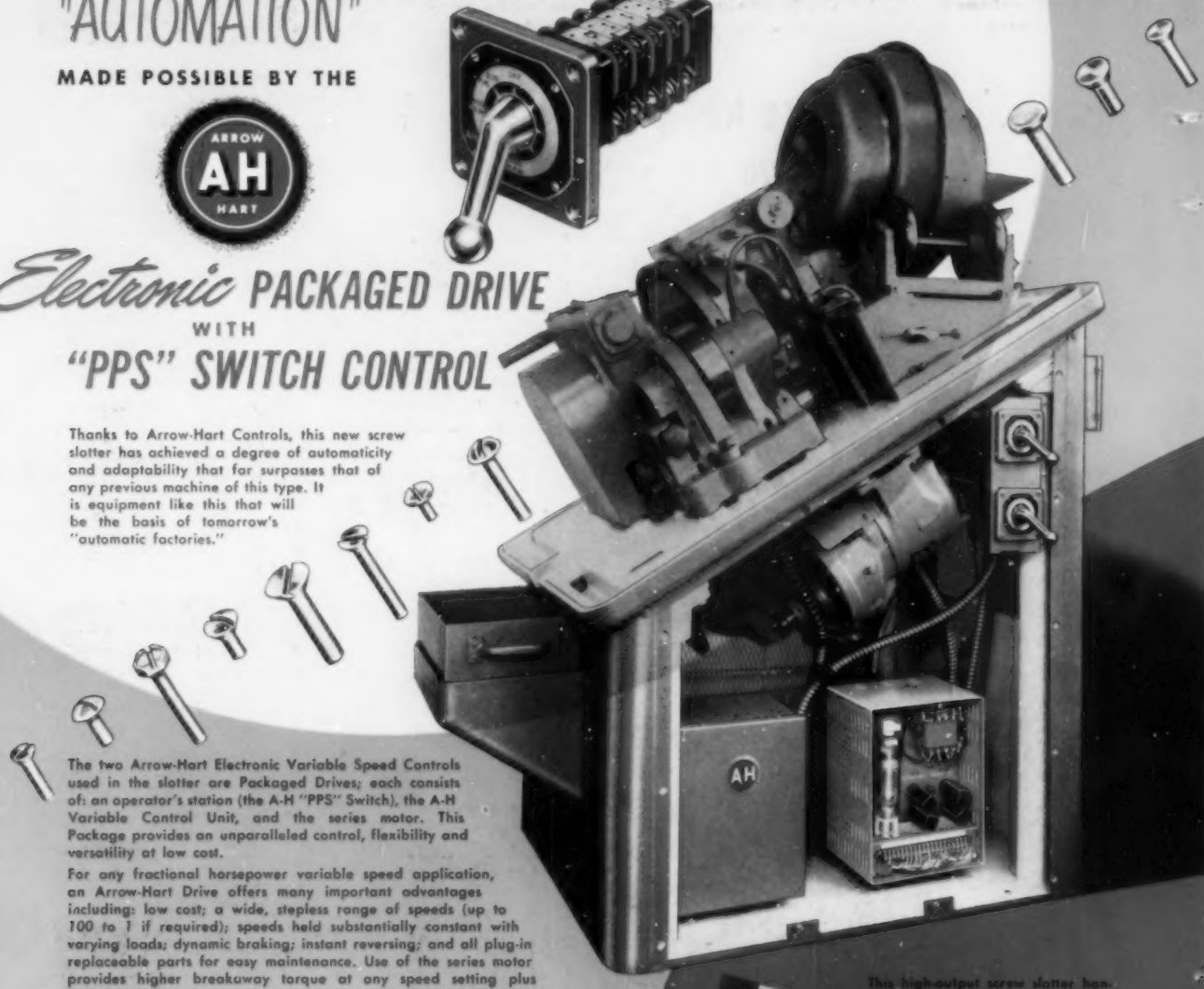
TURN THE PAGE FOR ADDITIONAL INFORMATION

Here's another important step in Machine Tool "AUTOMATION"

MADE POSSIBLE BY THE

ARROW AH HART

Electronic PACKAGED DRIVE WITH "PPS" SWITCH CONTROL



Thanks to Arrow-Hart Controls, this new screw slotter has achieved a degree of automaticity and adaptability that far surpasses that of any previous machine of this type. It is equipment like this that will be the basis of tomorrow's "automatic factories."

The two Arrow-Hart Electronic Variable Speed Controls used in the slotter are Packaged Drives; each consists of: an operator's station (the A-H "PPS" Switch), the A-H Variable Control Unit, and the series motor. This Package provides an unparalleled control, flexibility and versatility at low cost.

For any fractional horsepower variable speed application, an Arrow-Hart Drive offers many important advantages including: low cost; a wide, stepless range of speeds (up to 100 to 1 if required); speeds held substantially constant with varying loads; dynamic braking; instant reversing; and all plug-in replaceable parts for easy maintenance. Use of the series motor provides higher breakaway torque at any speed setting plus faster acceleration.

Especially where multiple operations or settings are required, the "PPS" Switch adds greatly to economy, versatility and efficiency. Acting in place of push buttons, relays and contactors, it provides safer, more convenient single point control. The operator can move from any position on the dial to any other position without activating any of the intervening circuits. Up to 16 positions are available from one compact control station.

This high-output screw slotter handles a wide variety of screw sizes, types and materials. Operation, including de-burring, is completely automatized. Screw blanks are simply placed in the hopper on the top; finished work is discharged into the work basket at the front. The machine is manufactured by the Gros-ite Manufacturing Company, Inc., Hartford, Conn., and is sold exclusively by Roy Machinery and Sales, Inc., also of Hartford.

Send Now FOR COMPLETE Control INFORMATION

AH

Industrial Control Division
THE ARROW-HART & HEGEMAN ELECTRIC COMPANY
103 Hawthorn Street, Hartford 6, Conn.

Please send me complete information about the Arrow-Hart

☐ Electronic Packaged Drive ☐ "PPS" Switch ☐ "RA" Motor Controls
☐ Push Button Controls ☐ Air Conditioning Controls

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CITY _____ ZONE _____ STATE _____

ARROW·HART

INDUSTRIAL CONTROL DIVISION
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HARTFORD 6, CONN., U.S.A.

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Sales Engineers in Columbus, O., Fayetteville, New York, Manchester, Ct., Seattle, Springfield, Mass., York, Pa.
Canada: Arrow-Hart & Hegeman (Canada) Ltd., Mt. Dennis, Toronto.

Printed in U.S.A.

NATIONAL OIL SEAL LOGBOOK

Write our Redwood City office for reprints of this Logbook page

Sealing News & Tips

Using high-pressure National O-Rings in low-pressure Sprague nylon wiper motor

Skilled engineering plus a new solution to an old sealing problem are found in the new Sprague "Mighty Midget" nylon windshield wiper motor.

The compact motor, designed for truck, bus, railway and aircraft use, weighs just 10 ounces. It is molded from DuPont Nylon and has only three moving parts. Leakage must be held to zero since, in vehicle applications, pressure is obtained from air brake systems. The air supply often contains detergent oils, dust, abrasive grit and moisture. Sealing must be positive and enduring despite operating temperatures from –45° to 200°F and the extreme wear resistance of molded nylon. The motor operates on 5 P.S.I. to 120 P.S.I. air, yet despite low pressure, high pressure O-Rings were accommodated by modifying design of the O-Ring retainers.

Sprague selected National O-Rings because they "compounded the specific material which satisfactorily meets the wide range of conditions to which our motors are subject." Sprague engineers also reported "minimum sticking" from National O-Rings. In numerous tests, these rings survived 5,000,000 cycles without noticeable wear. In one test, National O-Rings were operating satisfactorily after 19,000,000 strokes.

National O-Rings, like National Syntech* and National leather Oil Seals, are quality products, designed and produced by ultra-modern, precision manufacturing methods. Your National Applications Engineer has complete information. Call him for assistance next time you specify O-Rings or Oil Seals. He is backed up by the world's largest exclusive manufacturer of O-Rings and Oil Seals.

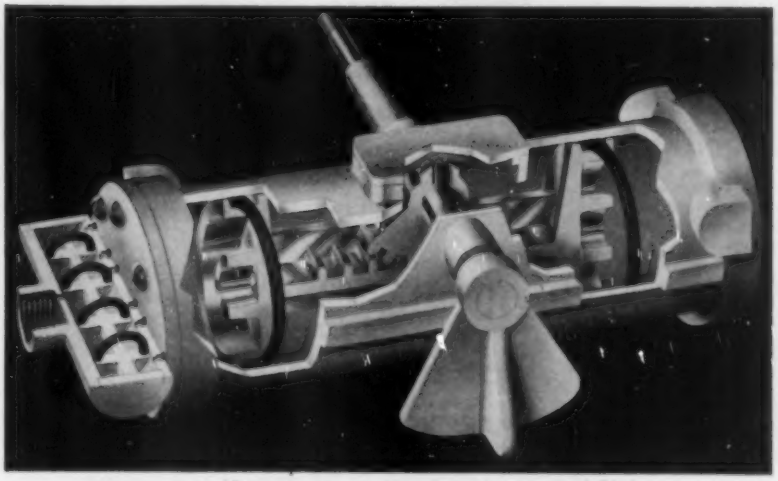
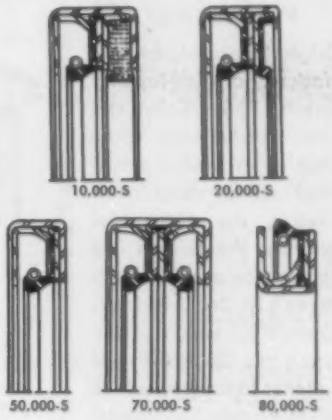


Figure 1—Sprague Nylon Windshield Wiper Motor

*T.M. Reg.

Standard-design National Syntech* Oil Seals are widely used in applications where intermittent temperatures reach 250°F, speeds reach 3,600 F.P.M. and run-out reaches .030 total indicator. These basic designs employ rigid, accurately manufactured steel outer cases, precision-tensioned springs and accurately molded and trimmed Syntech sealing lips. Syntech is unaffected by water, detergents, most lubricants and industrial fluids. Typical designs are shown below.



National O-Ring Catalog

National, a world leader in oil seals, offers a complete line of standard size commercial grade O-Rings. See the nearest National Applications Engineer for complete details or write factory direct for free catalog.

"Let Your Decision be Based on Precision"

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OIL & GREASE SEALS
O-RINGS SHIMS

NATIONAL MOTOR BEARING CO., INC.
General Offices: Redwood City, California
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NEWARK, N. J. . *Suite 814, 1180 Raymond Blvd., MItchell 2-7586*
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WICHITA, KANSAS . . . . *519 South Broadway, WIchita 2-6971*

Specify PARKER-KALON®

The Original SELF-TAPPING SCREWS

. . . make sure *planned* assembly savings *pay off*

Originator and largest manufacturer of Self-tapping Screws, Parker-Kalon can guarantee the proper combination of hardness and toughness, the sharp, clean threads, the dimensional accuracy, the uniform first quality you need to keep assembly trouble-free. Since P-K makes many types, you can fit the right fastener to the job, *not* the job to a particular fastener.

Type A
SLOTTED OR PHILLIPS

For light gage (.015 to .050") sheet metals, compositions, plywood, wood, etc.

Type Z
SLOTTED OR PHILLIPS
A.S.A. Type B

For light and heavy gage (.015 to .200") sheet metals, non-ferrous castings, plastics, plywood, compositions, etc.

HEX HEAD
Type Z
A.S.A. Type B

For light and heavy gage sheet metals and structural steel (.200 to ½"), non-ferrous castings, plastics, plywood, compositions, etc.

Type F
SLOTTED OR PHILLIPS

For ferrous and non-ferrous castings, bronze or brass forgings, heavy gage sheet metals, structural steel, plastics, plywood, etc. Cuts machine screw thread.

Type F-Z
SLOTTED OR PHILLIPS

For fastenings to thin sections and bosses in brittle plastics. Five cutting flutes distribute pressure evenly. Coarse threads resist stripping out.

HEAD STYLES

Types A, Z, F, and F-Z are available with any commonly used head styles

Type U
DRIVE SCREW

For permanent fastenings to ferrous and non-ferrous castings, heavy gage sheet metals, plastics, etc. Easily adaptable to press or hopper feed screw driving machines.

Type 21
DRIVE SCREW

For permanent fastenings of fibre, leather, fabric, etc., to sheet metal. Designed especially for fastening anti-squeak, upholstery, windlace, etc., to auto bodies.

SPECIAL FORMS

Variations of standard forms of all types of P-K Self-tapping Screws can be furnished on special order, quantity permitting.

STAINLESS STEEL

P-K Self-tapping Screws can be furnished to meet all requirements of applications where fasteners are subject to corrosive conditions. Made in Type 302 (18-8), Type 410, other metals as required. Ask for complete information.

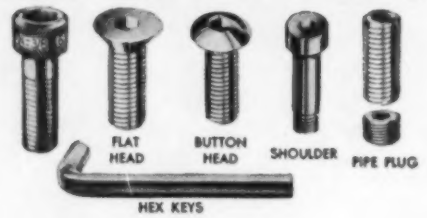
STAPS STAPS are P-K Fasteners with pre-assembled neoprene washers of various types. STAPS have many applications, such as effective control of leaks and electrolysis, prevention of squeaks under vibration, cushioning porcelain enamel or other brittle finishes against fastener pressure to avoid cracking. All types of P-K Self-tapping Screws, and Screwnails, are available as STAPS. Ask for complete information.

OTHER P-K FASTENERS

HARDENED SCREWNAILS

Fasten sheet metal to wood with nail-driving speed, but have over 4 times the holding power of nails. Do not work loose or back out.

Cold-forged WING NUTS and THUMB SCREWS



ASSEMBLY PLANNING AIDS

Catalogs, booklets, charts that give clear, complete information on every phase of P-K fastener selection and application. Typical is the 68-page P-K Engineering Standards book.

ASSEMBLY ENGINEERING SERVICE

At your request, a P-K Assembly Engineer will make recommendations based on a 35-year experience covering millions of applications. PARKER-KALON DIVISION, General American Transportation Corporation, 200 Varick St., New York 14.

IMAGINATION

makes the difference

For many years, we at Accurate have talked about our skill, experience and know-how . . . but other springmakers are unquestionably skilled, some have even more experience and must have accumulated a lot of know-how. Yet, what makes it possible for Accurate to so often devise new and better ways to make better springs at lower cost?

A customer gave us the answer in a single word—*imagination.*

If you would like to do business with an organization that has imagination . . . plenty of skill, experience and know-how . . . will approach your problems without necessarily being too influenced by conventional methods . . . send an outline of your requirements. There's no obligation and it may well be your first step towards getting better springs at lower cost. Write today. ACCURATE SPRING MFG. CO., 3815 W. Lake Street, Chicago 24, Illinois.

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ONLY MILLISECONDS
FROM TOUCH TO CLUTCH
FOR INCHING AND JOGGING
"No lost motion...
electro-magnetic principle
stops or starts drive
instantly!"
MASTER
OFF
JOG
STOP
REVERSE
"Locks in any position...no notches,
ratchet teeth, or lugs to engage!"

Warner Electric Brakes and Clutches speed, simplify machine setup six ways...

For fast response and fine-increment motion, it's hard to beat inching and jogging with a Warner Electric Clutch-Brake! Operators of machine tools, textile machines, paper and printing machinery, automatic packagers, and numerous other machines enthusiastically report faster, easier setup with electro-magnetic control of rotary drives. Here's why these new Warner units are ideal for inching and jogging applications:

1. **Remote, pushbutton control**—Pushbutton panel or switch may be located in position convenient to operator. Wiring is direct from control panel to clutch-brake . . . there are no actuating solenoids or valves to delay operation.

2. **Automatic switching**—The second you press or release the control button, you get simultaneous brake release and clutch pickup, or vice versa. Switching is automatically controlled by a relay in the panel.

3. **Instantaneous response**—Since actuating force (electric current) is same as brake or clutch motive force (magnetic flux), complete engagement and release are practically simultaneous with operator's touch. Permits maximum co-ordination of visual response with control action.

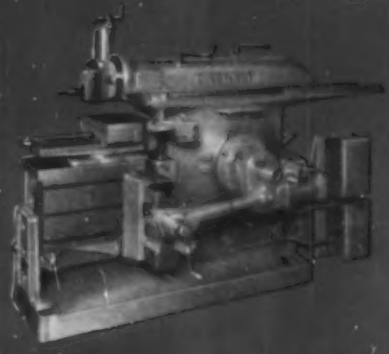
4. **No slipping or coasting**—Magnet and armature lock in full magnetic couple. There is no slipping or coasting . . . no creep, even under high inertia loads. Standard units have static torque ratings up to 700 ft. lbs.

5. **Rapid acceleration**—Clutch-brake coupling, direct connected to continuously running drive motor, produces rapid acceleration to maximum speeds. Saves wear and tear on motor . . . gives more adroit power transmission control.

6. **Locks in any position**—Magnet and armature have full 360° engagement. There are no ratchet teeth, notches, or lugs to engage . . . no clearances to take up. You get speed measured in milliseconds! If inching and jogging are critical on your machine, Warner Electric Clutch-Brakes will improve performance and control . . . build powerful sales appeals into your product. Discuss your design problems with a Warner field engineer, today!

Speeds accurate positioning of hub slide—instant, positive engagement of Warner Electric Clutch controlled by "jog" button simplifies and speeds positioning of slide in relation to work on Barber-Colman Gear Hobbing Machine.

Simplifies table positioning—Warner Electric Clutch-Brake, controlled by pushbuttons and action selector, offers complete cycle, jog, or continuous run operation of Hobbs Paper Trimming Machine.



Cuts setup time—Conventional control lever is eliminated . . . operator positions ram of Cincinnati Shaper corner, faster . . . with only a light touch on the toggle switch.

WARNER

Beat competition with

ELECTRIC BRAKES AND CLUTCHES

WARNER ELECTRIC BRAKE & CLUTCH CO., BELOIT, WISCONSIN

Warner Electric Brake & Clutch Co.
Dept. PE, Beloit, Wisconsin

Gentlemen: Please send new catalog describing Warner Electric Clutch-Brakes for improved inching and jogging—Bulletin No. 6115.

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Individual_____ Title_____

Address_____

City_____ State_____

TOUGH JOB?

Simplicity Model S-100 asphalt plant, one of five Simplicity plants owned by Blythe Brothers Company of Charlotte, North Carolina.

Throughout this Simplicity asphalt plant, many types of Link-Belt bearings furnish efficient shaft support. Inset shows the pug mill mixer that places perhaps the greatest demands on bearing performance. On this mixer four Link-Belt Series 6800 roller bearing pillow blocks withstand loads that result from mixing a 5,000 pound batch of hot asphalt, sand and coarser aggregate in one minute. Other Link-Belt products used in the Simplicity plant include precision steel roller chain drives, bucket elevators and screw conveyors.

LINK-BELT ball and roller bearings keep company with

READY ANSWER!

Asphalt plant builder standardizes on LINK-BELT BEARINGS

ONE of the toughest assignments for any bearing is in an asphalt plant. Temperatures up to 300°F . . . ever-present abrasive grit and dust . . . long hours of operation . . . sudden shock loads. Simplicity System Company of Chattanooga, Tenn., pioneered the use of anti-friction bearings on equipment of this type in 1925. And after trying many makes of bearings, they *standardized on Link-Belt* ten years ago.

It's the same story on more and more of America's hardest working machines. Design and consulting engineers find precision-built Link-Belt bearings the long-life answer to severe service conditions. Completely housing-sealed, these bearings maintain peak efficiency even with shaft deflection or misalignment.

There's a Link-Belt ball or roller bearing for almost every industrial need. And there's a bearing expert in the Link-Belt office near you to help you apply them. For complete engineering cooperation, call him today. Or write for Data Books 2550 and 2565.

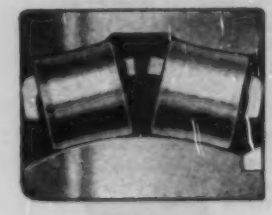
LINK-BELT

BALL AND ROLLER BEARINGS

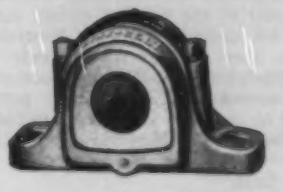
LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices, Stock Carrying Factory Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13.493-D

FACTS for design and consulting engineers:

Series 6800 Roller Bearing Pillow Blocks—used on the Simplicity plant—are part of Link-Belt's complete line of pillow blocks, flanged, flanged cartridge, cartridge, take-up and hanger blocks and unmounted bearings. Following are just four of their many outstanding features:

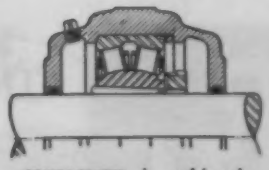


FREE-ROLLING—SELF-ALIGNING—The Link-Belt bearing adjusts immediately in all directions, assuring full load capacity even when subjected to shaft deflections and inaccuracies of mounting. These important features enable the bearing to readily sustain heavy, sudden shock loads.



END PLATE can be used for protection where shaft terminates at the bearing. No added machining is necessary.

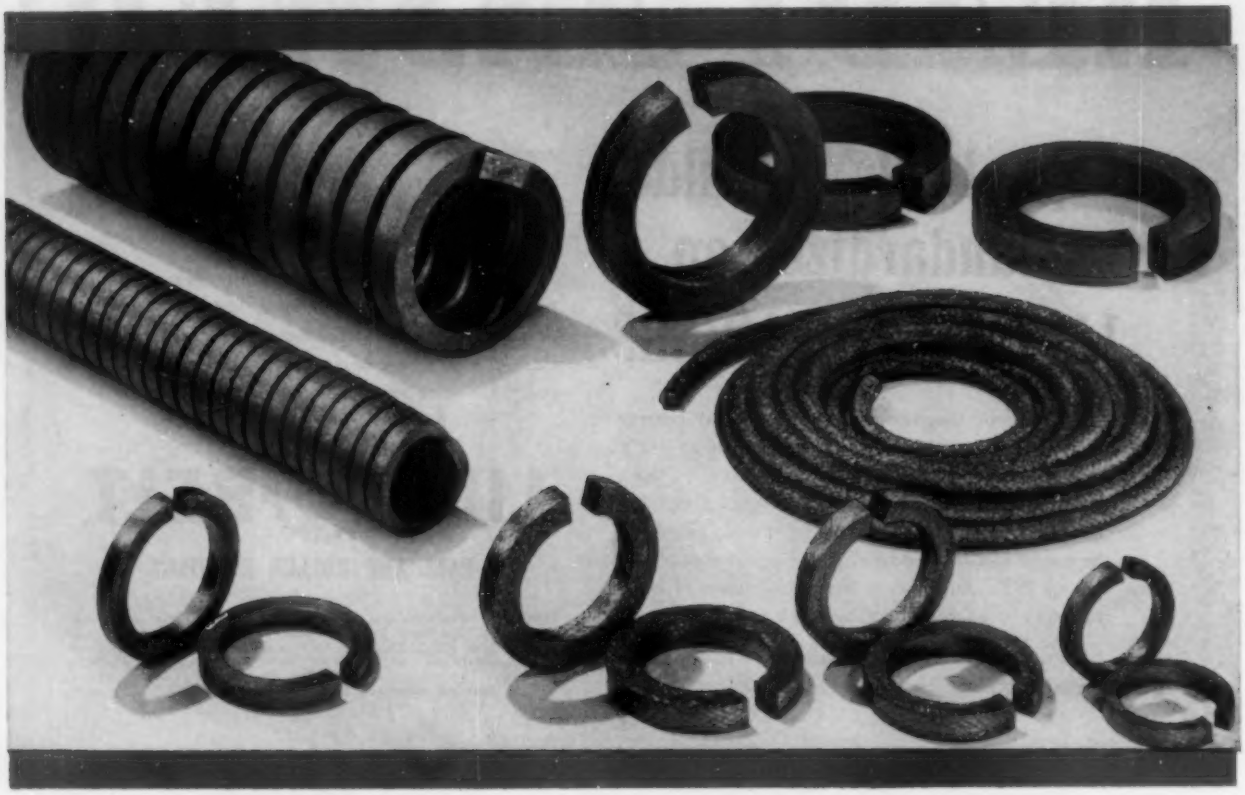
LUBRICATE WITH EITHER OIL OR GREASE—Spiral steel seals provide effective retention of either type of lubricant. What's more, housing sealing fully protects all moving surfaces.



COMPACTNESS is achieved with self-contained design. There are no external rotating parts to mar smooth appearance.

America's hardest-working machines

CALL ON R/M ENGINEERING SERVICE



R/M UNIVERSAL PACKINGS PROLONG EQUIPMENT LIFE

A pump or a valve stem is only as good as the packing in it. Pictured above is R/M's line of Universal Plastic Packings. They are engineered so precisely to pump and valve requirements that they permit the practice of preventive rather than corrective maintenance. Their lubricants, ground in during manufacture, are so securely locked within the compound that even after wear sets in, the effectiveness of the bearing surface remains unchanged. An unusually uniform dispersion of long asbestos fibers throughout the binder gives them a completely homogeneous construction and, therefore, tremendous stability under pressure. And because no organic materials are included—only the cleanest, softest, most open fibers obtainable—they have exceptionally high resistance to heat.

The complete R/M line includes packings and gasket sheets for use against air, gas, water, steam, oil, chemicals, solvents, food products and hydraulic fluids. R/M also makes a wide variety of "TEFLON"* products and an unusual number of asbestos textiles. If you have problems involving any of these materials or products, feel free to call on R/M's specialized engineering service.

**Du Pont's trade-mark for its tetrafluoroethylene resin*

For booklet shown, or other data, write, phone or wire:

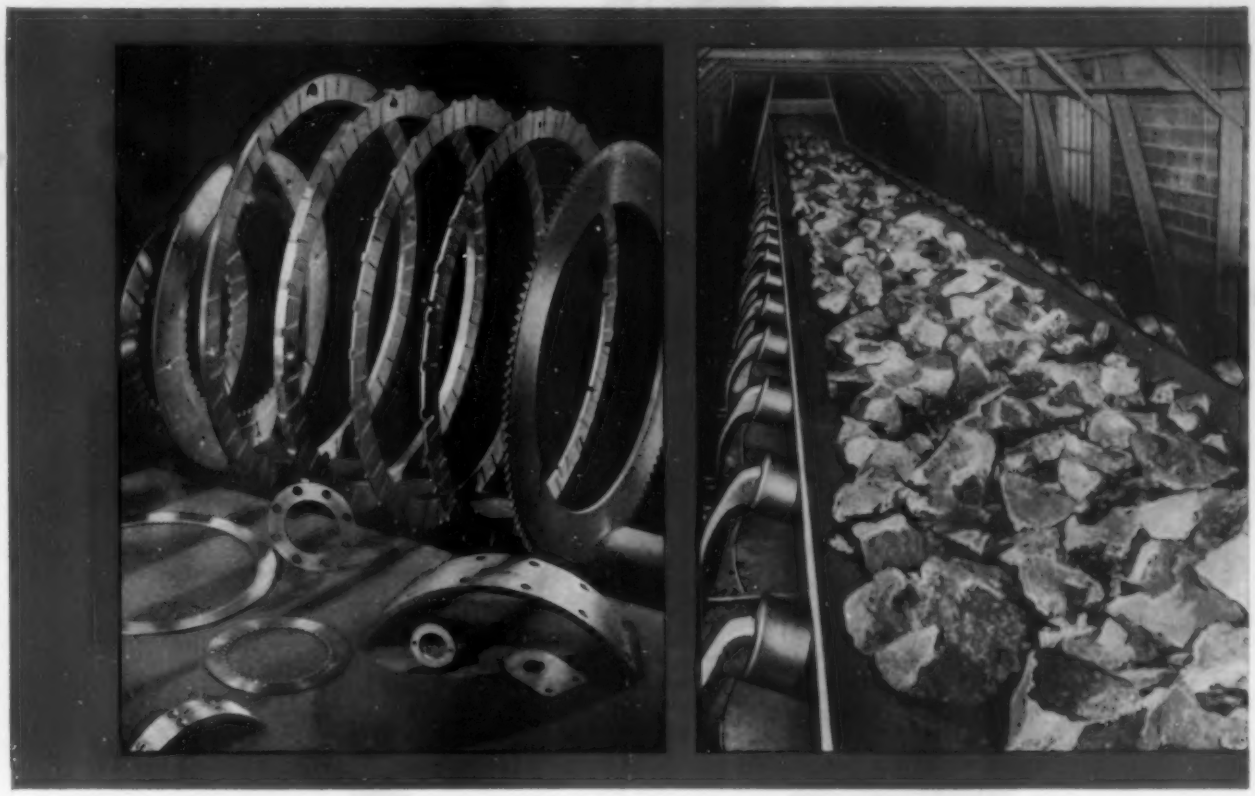
PACKING DIVISION OR ASBESTOS TEXTILE DIVISION
Raybestos-Manhattan, Inc.
Manheim, Pa.
Manheim 5-2211

R/M

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL, ENGINEERED PLASTICS

Brake Blocks, Linings and Clutch Facings | Fan Belts and Radiator Hose | Mechanical Packings and Gaskets | Abrasive and Diamond Wheels | Industrial Drive Belts | Industrial and Automotive Hose

FOR HELP IN SOLVING YOUR PROBLEMS



SINTERED METAL PARTS

If you have a friction material application that requires close tolerances or an operating condition that calls for immersion in oil, R/M can provide you with sintered metal parts engineered to your specific needs. It can also meet your requirements for woven and molded asbestos or semi-metallic materials. Feel free to call on R/M engineering service for advice on problems which involve any type of friction materials. For practical design and engineering data on R/M woven and molded asbestos friction materials and sintered metal, write for R/M Bulletin No. 500.

For Bulletin No. 500, or other data, write, phone or wire:

EQUIPMENT SALES DIVISION
Raybestos-Manhattan, Inc.
6010 Northwest Highway
Chicago 31, Ill.
ROdney 3-2400

Just off the press!

R/M CONVEYOR BELTS

The amazing new "XDC" Cover gives phenomenal resistance to wear, abrasion, cuts and tears on heavy duty R/M conveyor belts for grueling loads. The same XDC development also puts longer life into lighter service belts for portable and weighing conveyors, table and small parts conveyors, package conveyors, in food belts, flanged and ribbed belts. R/M custom-designs conveyor belts for any required condition, for resistance to heat, acid, oils, etc. If you have a design problem involving industrial rubber products . . . write to the Manhattan Rubber Division.

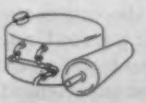
For booklet shown, or other data, write, phone or wire:

MANHATTAN RUBBER DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J.
GRegory 3-2000

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • No. Charleston, S.C. • Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

Conveyor Belts



Rubber Lined and Covered Equipment

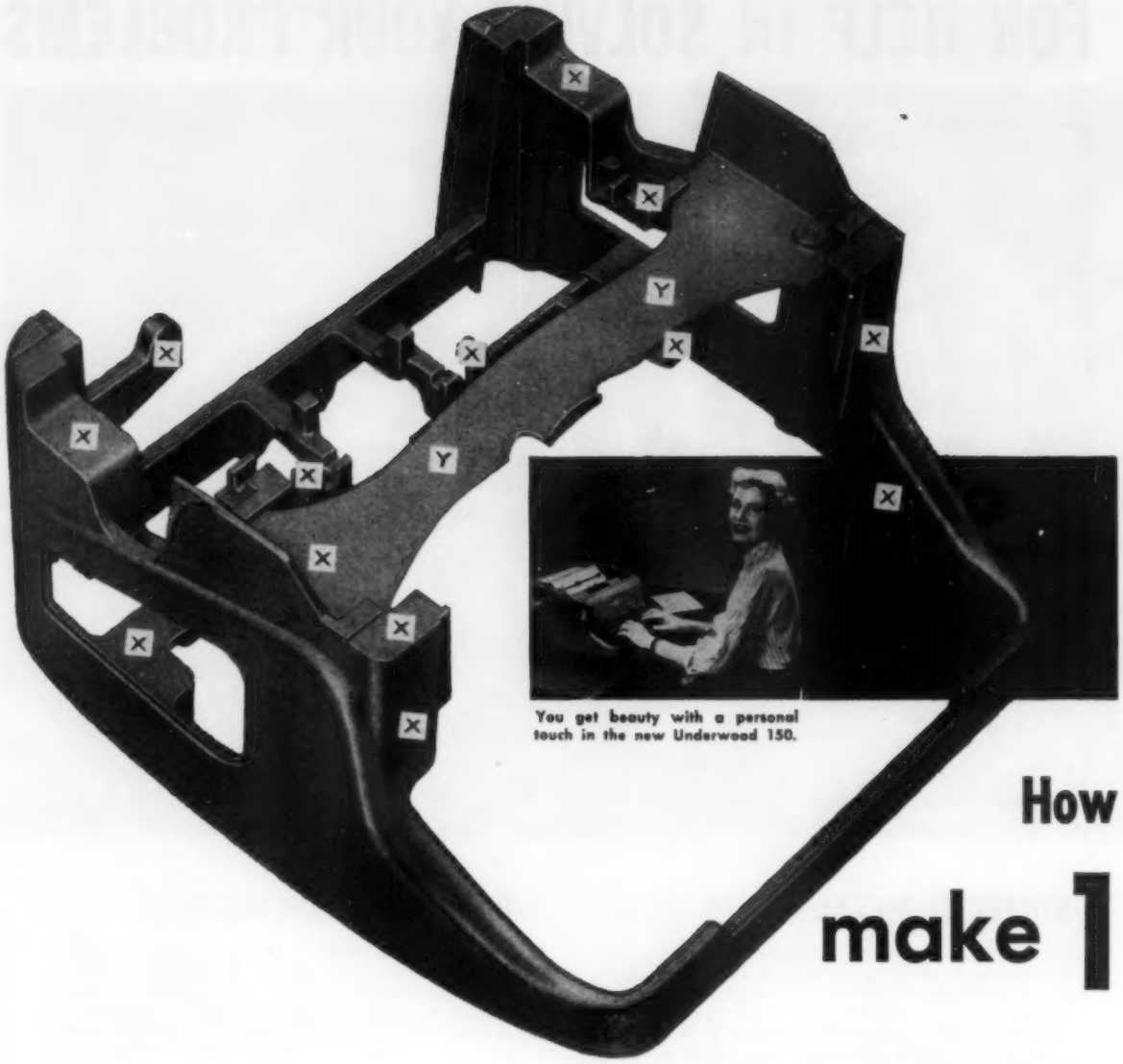
Sintered Metal Friction Elements

Asbestos Textiles

Teflon Tape, Packings, Sheets, Rods, Tubes

Engineered Molded Rubber and Plastics

R/M



You get beauty with a personal touch in the new Underwood 150.

How make 1

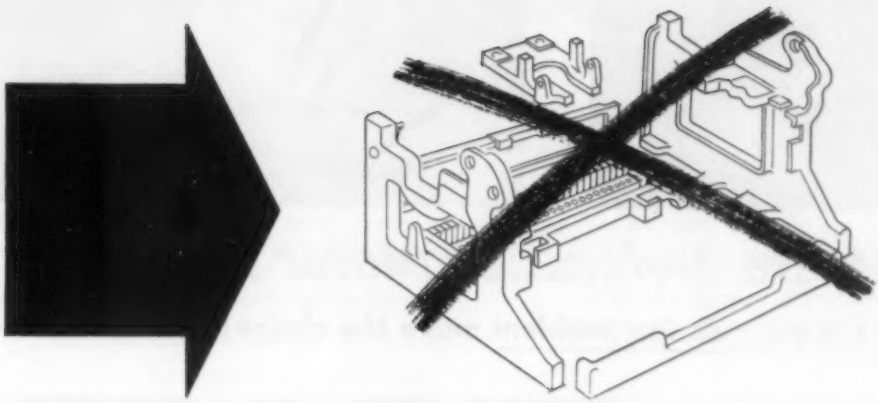
This is the die cast aluminum main frame in the new UNDERWOOD 150 standard typewriter.

It replaces six sand castings...saves 4½ pounds overall weight . . . eliminates frame assembly, much frame machining, and many fasteners and other small parts.

More than that, it highspots the hidden benefits you can build into a product with die casting when, like Underwood, you bring Doehler-Jarvis in at an early stage in design.

Look, for example, at the areas marked with an "x". Each is a spot where die casting effects a production saving . . . where, perhaps, die cast precision eliminates surface machining . . . or where a part is integrated into the original casting rather than assembled.

Notice, too, how the designers use the high strength characteristics of thin die cast sections. The one-piece homogeneous die casting gives Underwood a "built-in" rigidity and dimensional stability, eliminating size variations and "weave" often experienced in built-up assemblies. They use this property to "open up" sides and back of the frame for easy access in assembly and



Doehler-Jarvis helped Underwood

casting do the work of 6

service. They use it to provide vertical mounting for the mechanism and, thus, to eliminate drilled holes in exterior surfaces.

And see how ingeniously even the gate of the casting is employed. (See area "y".) It is left in position to provide rigid support and insure dimensional stability during drilling and machining. Only then is it discarded.

Now examine the dense, non-porous surface structure. It needs no dip coat and thus eliminates still another process step.

Like many another user of Doehler-Jarvis die castings, Underwood converts into product improvements the savings they realize through die casting. Their new UNDERWOOD 150 gives users a lot more typewriter than ever before – yet it costs no more.

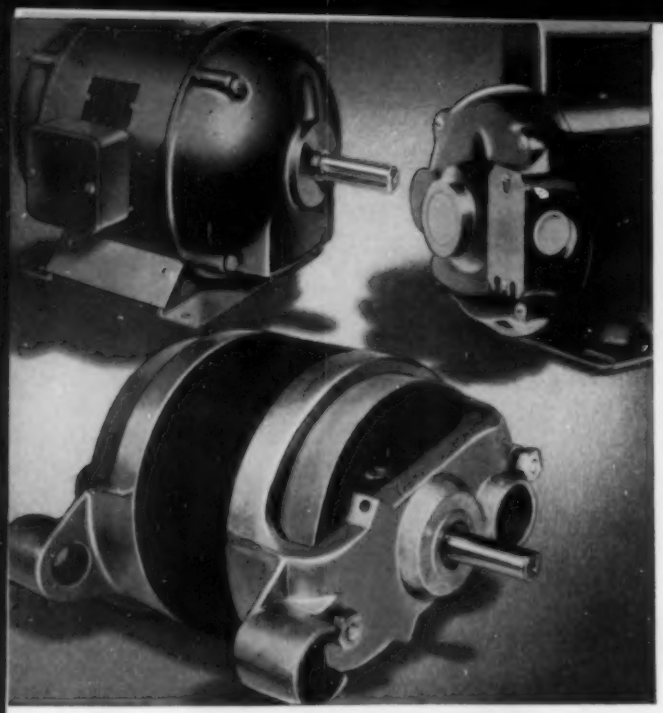
In its half century of die casting, Doehler-Jarvis has helped many producers, big and little, give customers more product for the money . . . among them some of the best known makers of automotive, electrical, communication, household, office and other types of equipment.

They count on Doehler-Jarvis for both the resources and the resourcefulness they need to take full advantage of the die casting process. You can count on Doehler-Jarvis, too.

So when you have a new product on the boards – call in Doehler-Jarvis.

Doehler-Jarvis Division
of
National Lead Company
General Offices: Toledo 1, Ohio

*Reg. U. S. Pat. Off.



Complete Motors... or Motor Parts

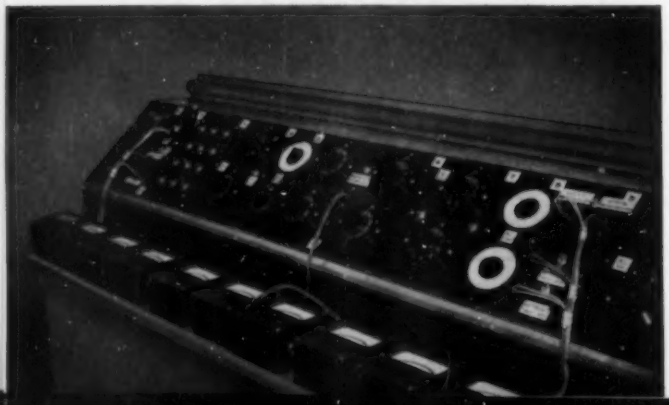
Let your design problem make the choice!

Standard motors and matched motor parts represent only the beginning of what R & M is qualified to build! Special R & M fractional-horsepower with *any* housing design—or specially designed motor parts to fit your housings—are regular R & M contributions to products such as those listed at right:

Portable Saws	Vacuum Cleaners	Portable Grinders
Drills	Files	Sirens
Nut Setters	Sanders	Hair Driers
Hammers	Pumps	Advertising Devices
Routers	Compressors	Ventilating Equipment
Screw Drivers	Hones	Oil Burners
Hedge Trimmers	Business Machines	Surgical Instruments
Lawn Mowers	Cast Cutters	Grease Guns
Nibblers	Food Mixers	Vibrators
Lock Mortisers	Polishers	Die Sinkers
Valve Grinders	Planers	Waxers

The machine that tests motor performance . . . in minutes instead of months!

Formerly it took months to do a really thorough job of calculating motor performance and requirements for a given job. Now, using the unique R & M "Electrical Slide Rule," the performance of any one motor design can be calculated in about 20 minutes! Result? R & M can engineer a motor to your exact requirements . . . thoroughly, accurately, *and in time to meet your production and marketing schedules!*



You can expect quality . . . from every Robbins & Myers motor!

Here, for example, are some of the quality features built into R & M universal motor parts:

1. Every field coil has paper in the slots—in addition to standard taping. More insulation means longer motor life, fewer failures.
2. Insulating material is selected for the job. For example, glass insulated wires are used in sander and saw motors.
3. R & M motors are varnish-dipped and baked—as much as *three times* when service requires it.
4. Standardized commutators and laminations—for mass-production at no sacrifice in quality.
5. Diamond-turned commutators . . . for greater concentricity and smoother surface finish. Brushes last longer!
6. Matched Motor Parts are precision-built, 100%-tested, dynamically balanced, fully interchangeable.

How to select the best Fractional Horsepower Motors FOR MACHINES, POWER TOOLS, APPLIANCES

The most important single factor in motor performance is *selection* of the right motor for the job. That's why R & M offers such a wide variety of types and sizes of motors and motor parts. From these many standard and special-standard types we can, in most cases, help you select the motor to help give your product the best all-around performance.

We Also Custom-Design, Economically!

Your problem may require a custom-designed motor. If so, we'd much rather work out a special motor for you than see you take an "off-the-shelf" compromise.

Ordinarily the extensive calculations required make custom-designing pretty expensive. We've licked that problem, too, with the unique R & M "Electrical Slide Rule." This is an electrical motor-performance calculator. With it, the designer can reduce the work of a whole day or two to about twenty minutes! Naturally you and we both benefit.

Some Other Advantages of R&M Motors

R & M offers some special construction features: extra insulation; glass insulation where heat requires it; diamond-turned commutators; extra varnish treatment; a gratifyingly low failure rate.

As a pioneer in the small motor field, we have designed and built millions of small motors for thousands of different applications. And so we naturally feel well qualified, with engineering skill and experience, and extensive manufacturing facilities, to do an exceptionally good job for you. At least, it won't cost you anything to find out.

Let Us Tell You More

Call the nearest branch office for an R & M Motor Specialist—or write us for the information in which you are interested. Use the check list below.

ROBBINS & MYERS, INC., MOTOR DIVISION, PD
Springfield 99, Ohio:

Please send me, without obligation, information on:

- ☐ Motor Parts for Portable Tools
- ☐ Universal Motors
- ☐ Capacitor Motors
- ☐ Universal and DC Motors
- ☐ R & M "All-Weather" Motors—up to 125 HP
- ☐ Please have a Motor Specialist call

Product we manufacture: _____

Name _____ *Title* _____

Company _____

Street _____

City & State _____

R&M MAKES BOTH!
Fractional horsepower motors and parts . . . from 1/200 h.p.

If it's an R&M, it's the Right Motor!

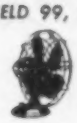
Integral Horsepower motors; famous R&M "All-Weather"* motor with sealed bearings. Up to 125 h.p.

*"*All-Weather*" *is an R&M trademark*

ROBBINS & MYERS, INC.

SPRINGFIELD 99, OHIO • BRANTFORD, ONTARIO

Fractional & Integral h.p. Motors & Generators


Electric Fans

Electric & Hand Hoists & Cranes

Moyno Pumps

Propellair Industrial Ventilating Equipment

Unlimited range of size, grade, finish

—helps make U·S·S Amerstrip

America's preferred strip steel

WE can supply any strip steel you need, in any quantity you need, and we get it to you *when* you need it. That's why U·S·S Amerstrip is more widely used in a greater variety of products than any other strip steel.

Amerstrip comes in a complete range of analyses and tempers in carbon, stainless, and alloy steels . . . in coils or cut lengths . . . with a round or square, natural or rolled edge . . . and in all commercial finishes.

If you have any question about the selection or use of strip steel, write to American Steel & Wire, Room 842, Rockefeller Building, Cleveland 13, Ohio.

Amerstrip

USS

AMERICAN STEEL & WIRE DIVISION
UNITED STATES STEEL CORPORATION
GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA., SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

4-30

UNITED STATES STEEL

Where will you put this remarkable plastic to work?

No matter what you make, BAKELITE Polyethylene offers you properties worth investigating. Here's a material that remains flexible even at below-zero temperatures . . . with excellent dielectric properties, high impact strength. It's highly chemical resistant, and lightest in weight of all plastics. It can be fabricated by molding, blow molding, extrusion . . . by every process used with plastics. And BAKELITE Polyethylene is in an increasingly favorable position for your planning—with increasing supplies at decreased prices, *59 percent reduction* since 1943. For a broad picture of how you may benefit send for your free copy of BAKELITE Polyethylene. Write Dept. UR-10.

Polyethylene first made possible insulation for high-frequency radar equipment. Then, TV lead-in, wire and cable insulation benefited by its unique properties.

Came the polyethylene squeeze bottle—revolutionizing an industry, supercharging marketing for now over 2,000 products requiring over 75,000,000 bottles.

And more and more pounds of polyethylene go into lightweight, chemical-resistant pipe for farm and industrial water supplies, chemical and medical tubing.

Safer chemical carboys and acid bottles of polyethylene are unbreakable; their light weight brings substantial savings on shipping and handling charges.

Polyethylene film . . . stronger, attractive, easily sealed . . . packages sales appeal and protection around hundreds of items from fresh and frozen foods to shirts.

From moldings to laminations with other materials, the remarkable properties of polyethylene are making products that look better, sell better, and work better in every industry.

BAKELITE Polyethylene

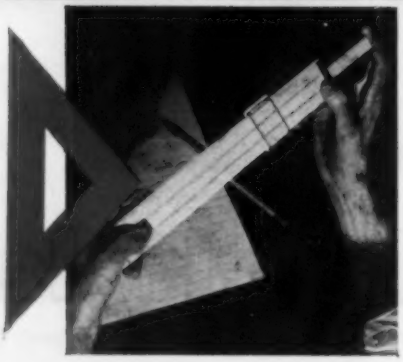
TRADE-MARK

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N.Y.

In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Belleville, Ontario

Why does the PARAGON® "up" drafting room output, and easier for

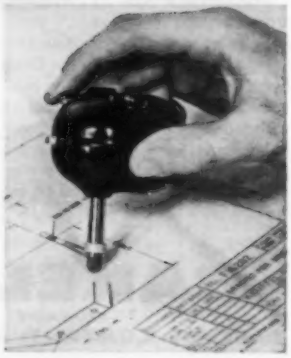
THE RIGHT ANGLE



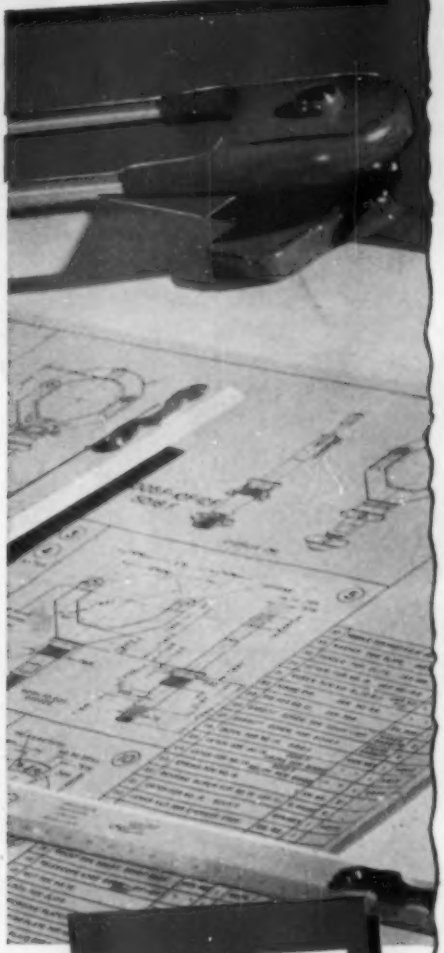
The first American-made slide rule was a K&E, and generations have known these rules for their precision, readability and velvet-smooth operation.

After you've once used a K&E MOTORASER,† you'd no more go back to hand erasing than you'd take to drawing with your gloves on.

†Trade Mark



make life draftsmen?

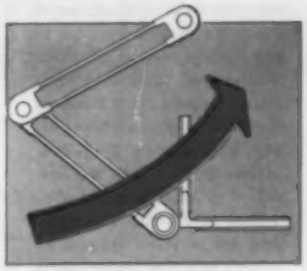


K+E

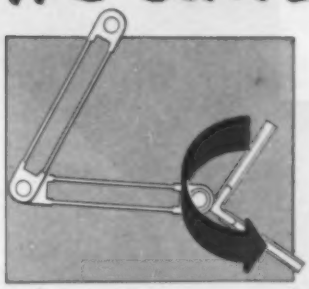
partners in creating

Because it's FAST

The Paragon Drafting Machine operates on the basic parallelogram principle. Three drums of precisely equal diameter are fitted with non-slipping bands. Top drum is fixed so that it cannot turn. Wherever you move the Paragon over the entire working area, you can draw precisely parallel lines: horizontal, vertical, or at any angle.



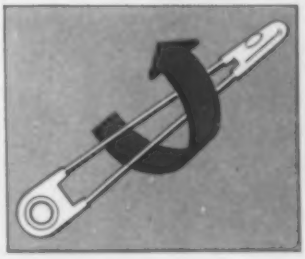
It's CONVENIENT



The Paragon is controlled entirely with your left hand, leaving your right hand free to draw. A slight pressure on the control ring gives you any common angle and its complement. All lines are drawn to exact length as you go, with no "tails" to erase later. When you're not using your Paragon, you simply park it out of the way on the anchor step.

It stays ACCURATE

Open-center arm construction, with no rigid center member, makes it practically impossible to disturb band length and factory-set tension. Even when the arms are twisted somewhat, as they must be when the head is lifted off the board, the dimensions of the rigid tubes and assembly remain unchanged. Scales continue to make exactly parallel lines straight out to the end.



It CUTS COSTS too

The Paragon eliminates hundreds of waste motions that the draftsman would have to make with hand equipment. It stays true and easy to operate throughout its entire life. It pays for itself in a matter of weeks, continues to cut costs over the years!

That's Why We Say . . .

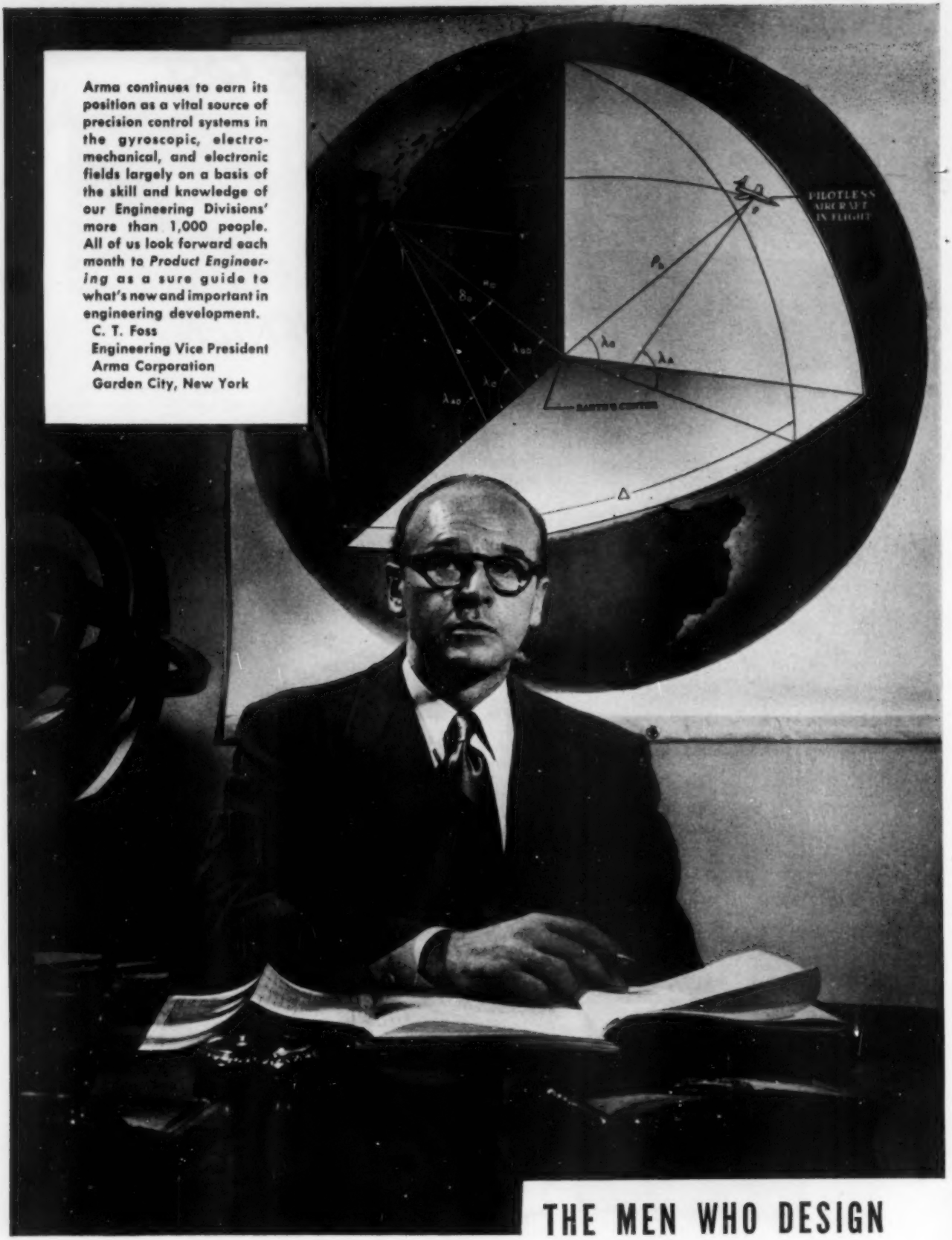
IT'S QUICKER, EASIER, NEATER, WITH A PARAGON!

KEUFFEL & ESSER CO.

Est. 1867

NEW YORK, N. Y. HOBOKEN, N. J.

CHICAGO • ST. LOUIS • DETROIT • SAN FRANCISCO • LOS ANGELES • MONTREAL



Arma continues to earn its position as a vital source of precision control systems in the gyroscopic, electro-mechanical, and electronic fields largely on a basis of the skill and knowledge of our Engineering Divisions' more than 1,000 people. All of us look forward each month to *Product Engineering* as a sure guide to what's new and important in engineering development.

C. T. Foss
Engineering Vice President
Arma Corporation
Garden City, New York

THE MEN WHO DESIGN

He Leads Engineering at Arma

HE READS PRODUCT ENGINEERING

You advertise here to put the power and influence of design-engineering's No. 1 magazine behind your products.

For many years, the companies which sell to the giant Original Equipment Market have recognized the basic influence of product-design engineers in this $30-billion market's purchases of their parts, materials, components, or finishes.

Just as importantly, they have long made *Product Engineering* their basic advertising medium in this market. Year after year, *Product Engineering* carries far more advertising than any other magazine edited for the O.E.M.'s primary buying group.

The reasons why it does are important to *you*, and to the sales future of your products. And although your nearest *Product Engineering* representative can give you many more reasons for this magazine's unmatched advertising values, the basic ones are these:

(1) *Product Engineering* is the only magazine, edited for them, that design engineers pay to read.

(2) Over 26,000 of your best customers and prospects now subscribe to *Product Engineering* because it gives them job help and information nowhere else available.

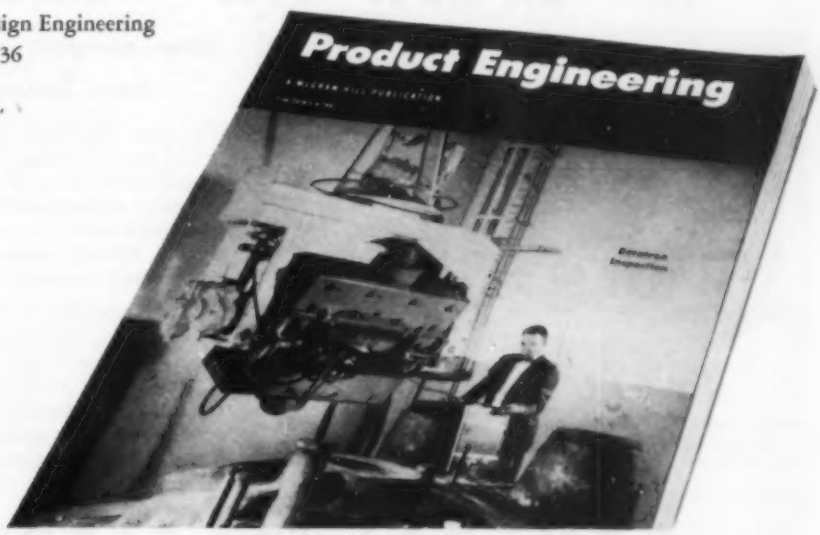
(3) Because its editorial voice is listened to wherever new products are designed, its advertisers also command the attention of the men who decide *who gets the business* in the O.E.M.

In 1953, 880 advertisers put *Product Engineering's* power behind 4,422 advertising pages. There's no better time than now to let this magazine work for *you*.

The McGraw-Hill Magazine of Design Engineering
McGraw-Hill Building, New York 36

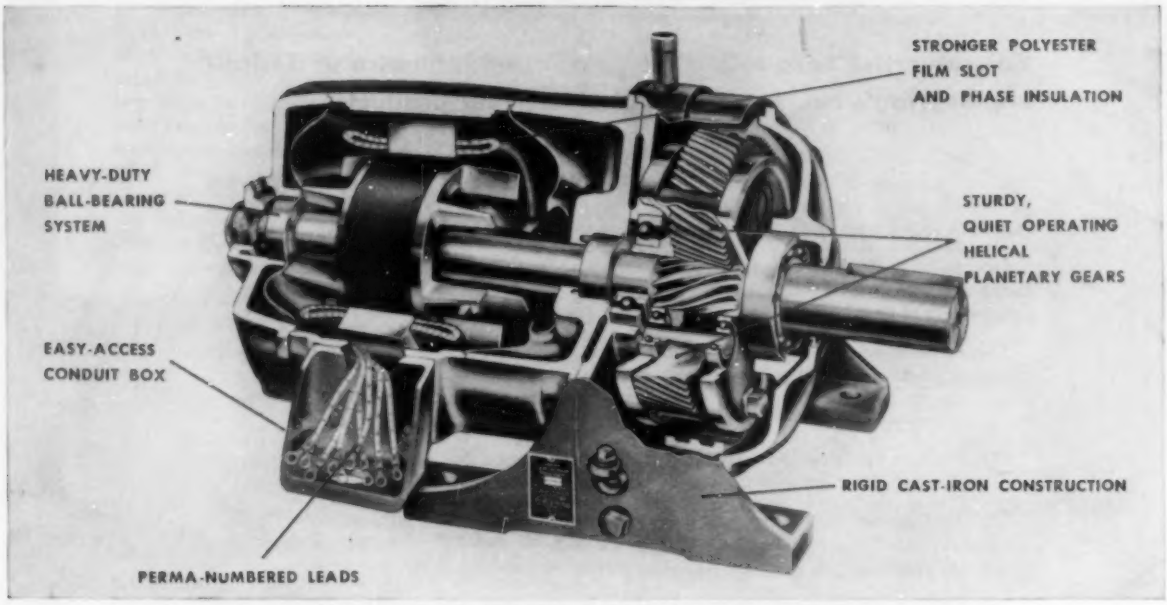
DISTRICT OFFICERS: Atlanta 3, Boston 16, Chicago 11, Cincinnati 8, Cleveland 15, Dallas 1, Detroit 26, Los Angeles 17, New York 36, Philadelphia 3, Pittsburgh 22, San Francisco 4, St. Louis 8

ABP ABC



AMERICA'S NEW PRODUCTS READ PRODUCT ENGINEERING

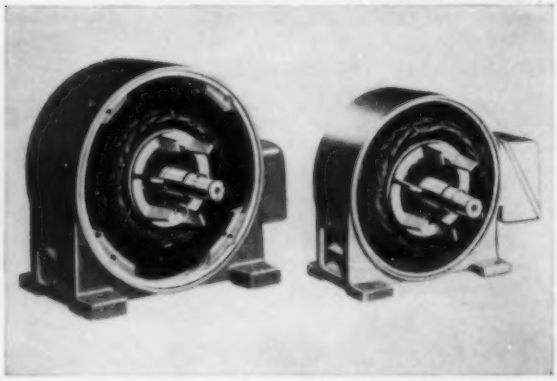
Designer's



CUTAWAY VIEW OF SINGLE-REDUCTION TRI/CLAD '55' GEAR-MOTOR

Now G-E gear-motors are built with the all-new TRI 55 CLAD motor

REG. U.S. PAT. OFF.



MORE COMPACT FRAME of new Tri/Clad '55' motor (shown at right) makes new G-E gear-motor lighter, smaller, with full power rating of previous models. More floor space is thus freed for aisle room or machinery.

New compact motor design gives you more horsepower in less space

The new Tri/Clad '55'—the foremost advance in the art of motor design—is now an integral part of a completely new line of G-E gear-motors. A neat, well balanced arrangement of motor and gears gives you the low-speed drive you need for your most modern machine design. Unused space has been reduced to make this motor easier to handle and easier to install.

When you select G-E gear-motors you eliminate the necessity of ordering, assembling, and maintaining separate parts to get the drive you want. The new line covers a wide range of power ratings, voltages, speeds mounting arrangements and enclosures. Lighter weight reduces shipping and handling costs. For the entire G-E Tri/Clad '55' gear-motor story, see Bulletin GEA-6027.

GENERAL ELECTRIC

Digest

MOTOR & CONTROL HIGHLIGHTS

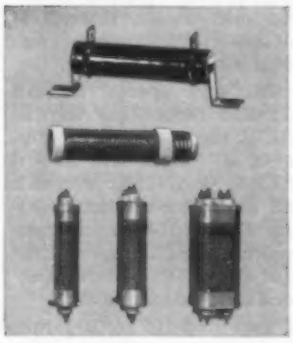
EASY-TO-MOUNT FIELD RHEOSTATS PERMIT ACCURATE SPEED ADJUSTMENT

Plate-type

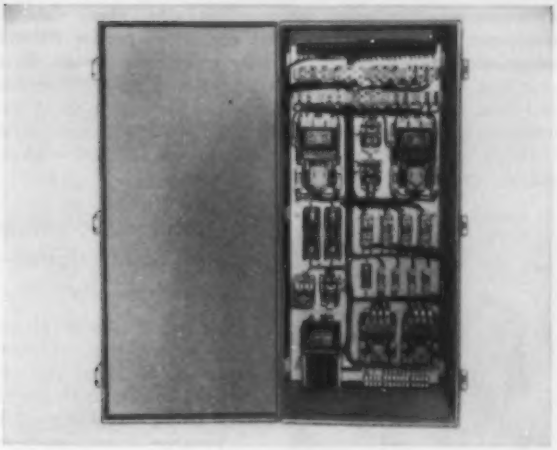
Tube-type

For speed control of d-c motors, or voltage control of generators and exciters, you'll want a General Electric field rheostat. Both plate-type and tube-type can be manually, chain or motor-operated to suit your particular machine-tool application. Accuracy of speed adjustment is provided, in most cases, by over fifty divisions of resistance. To give added flexibility adjustable stops may be located at any position between ends of travel. Special alloy resistance material assures long life. Four-point mounting simplifies installation and eliminates the need for additional feet or brackets. Three plate-type sizes are available: 12-inch with 70 resistance steps, 9-inch with 52 steps, and 6-inch with 27 steps. For further information send for Bulletin GEA-3222.

ENAMELED RESISTORS WITHSTAND EXTREME TEMPERATURE CHANGES



Here's a big selection of General Electric enameled resistors designed to withstand sudden and extreme temperature changes without damage. Simplest control product manufactured, each unit has a standard ±5% resistance tolerance, which makes it extremely adaptable for innumerable design applications. A vitreous enamel coating, applied after winding, gives mechanically airtight and moisture-proof construction, provides long life. The low temperature coefficient of the nichrome wire permits resistance to remain nearly constant as temperature increases. Circular-band terminals or wire leads are furnished as desired. For complete information, request Bulletin GEC-817.



Save 4 ways with custom-built G-E industry control panels

General Electric custom-built industry control panels can save you time, effort and cost. That's because G.E. designs and tests these panels for your specific applications. Your results are as follows: (1) **You reduce** the load on your own design and drafting staff, releasing them for other projects. (2) **You save** on inventory and storage costs of components. (3) **You eliminate** assembly and wiring and cut installation costs. (4) **You avoid** the need to set up a separate maintenance organization to service the control panel. G.E's extensive service facilities includes 31 Apparatus Service Shops throughout the country. For further information, see your G-E Apparatus Sales representative.

General Electric Company, Apparatus Sales Div.,
Sec. C668-112
Schenectady 5, New York

Please send me the following Bulletins:
√ for reference purposes × for immediate projects
☐ **GEA-3222 Field Rheostats**
☐ **GEA-6027 Tri/Clad '55' Gear-motors**
☐ **GEC-817 Enameled Resistors**

CONSULT YOUR SWEETS PRODUCT DESIGN FILE. You'll find "everything electric" for machinery manufacturers in the General Electric Section.

Name.....

Company.....

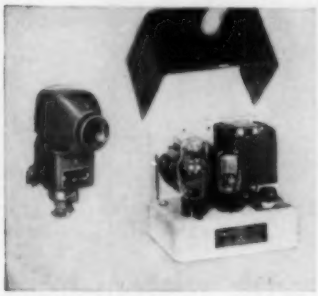
Street.....

City..... **State**.....

TURN PAGE FOR MORE G-E PRODUCT HIGHLIGHTS

G-E ELECTRONIC RELAYS HELP SOLVE MANY DESIGN PROBLEMS

A complete line of General Electric relays, ranging from low to highly sensitive units, are now available. These versatile electronic devices give you fast operation, precise control, automatic operation, and flexibility in machine design. Each unit and standard accessory is simple to install, adjust and maintain. Various enclosures for specific applications are available in the line. Here are two types of standard G-E relays that can help you solve a great many complex design problems quickly and easily.



Photoelectric relays sort, count, signal—automatically

Now G.E.'s simple photoelectric relays can cover up to 600 operations, and in combination with standard accessories it is possible to meet an even wider range of applications. G-E photoelectric relays provide an inexpensive way to accurately, automatically control many operations for large industrial and small commercial installations.

Changes in light-level settings are easily made by means of an adjustment knob. It only takes a few seconds for light source or phototube holder to be focused and aimed.

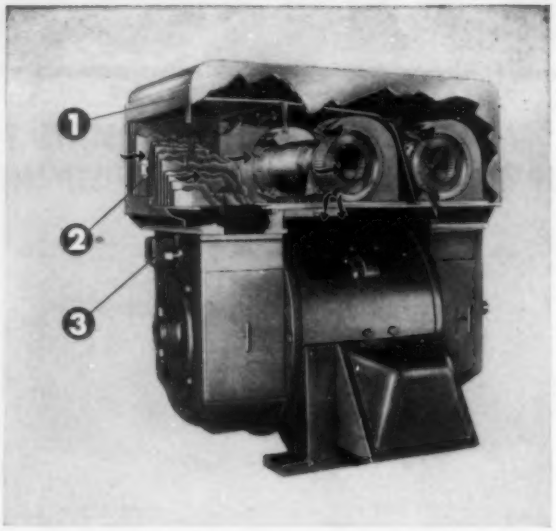
High contact ratings that meet NEMA standards eliminate need for auxiliary relays in most applications. Sturdy construction means dependable operation and extra-long service life. Enclosures help to protect against shocks and vibration. See Bulletin GEA-5921.

New electronic relays have high sensitivity

This new electronic resistance-sensitive relay is able to amplify minute currents carried by very delicate contacts. Even a wet thread will provide enough signal for it to operate.

Sensitivity level is set by adjusting dial, which can be locked in place. The relay may be remotely controlled from as far away as 500 feet. Each can be set for either "normal" (relay "drops-out") or "reverse" (relay "picks-up") operation of the magnetic relay included in the device.

Built for long life, its enclosure is weather-resistant and dust-tight. Terminals are easily accessible; all components of this G-E relay are open for ease in servicing. For further information send for Bulletin GEA-5893.



New G-E Unit-cooled D-c Motor, Small, Compact, Easy to Install—Protected from Dust, Dirt, Grit

General Electric's new totally enclosed unit-cooled d-c motor assures you of dependable operation even in severe atmospheres. It is a completely self-contained unit with no external duct work or air filters to install.

This new motor has two independent air flow systems—one is external (black arrows)—the other recirculates air internally (red arrows). An air-to-air heat exchanger, part of the unit cooler, dissipates heat losses without permitting interchange of air between internal and external circuits.

New ventilation arrangement and special design features of the G-E unit-cooled motor (as shown above) include: (1) COMPACT, top-mounted cooling unit which is within the over-all length and width of the main motor. (2) SELF-CLEANING vertical plates are smooth and need little maintenance. (3) TWO BLOWERS operating the double-ventilation system are powered by separate TEFC motors independent of the main motor speed. This allows the d-c motor to use its full speed range capabilities.

Available in *all* standard ratings from 15 to 200 hp, in constant or adjustable speed types. There is a standard G-E unit-cooled d-c motor ready to go to work for you.

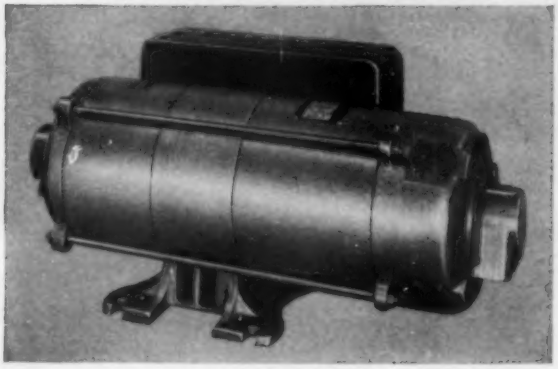
For additional information on this new motor design, send for Bulletin GEA-6091.

GENERAL ELECTRIC

Designer's Digest

PRODUCT HIGHLIGHTS

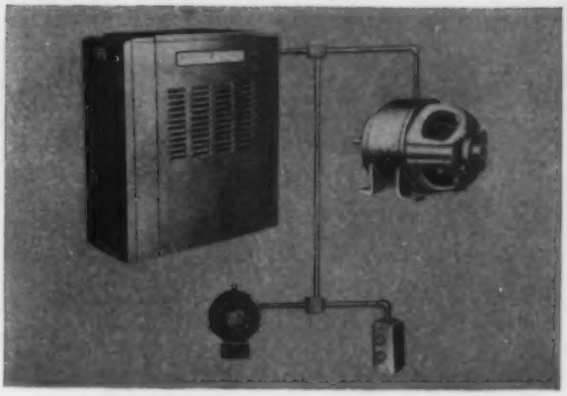
G-E AMPLIDYNE GIVES FASTER, MORE VERSATILE CONTROL



Put the General Electric amplidyne to work for you to improve and simplify machine operation and increase production. It provides fast, accurate control of position, torque, speed, voltage, or tension. Basically, the unique use of a short circuit and compensating winding creates such precise electrical balance that the smallest electric signals release ***kilowatts*** of output capable of controlling the most powerful machinery. G-E amplidyne assures instant response; full output is reached in 1/10th of a second or less. See the new full-color 24-page booklet "THE AMPLIDYNE—THE SHORT CIRCUIT THAT MOVES MOUNTAINS." Check Bulletin GEA-4053.

G-E PROCESS TIMER CUTS WASTE ON REPEAT CYCLES

On those repeat cycles of opening and closing contacts where percentage of "on" time of double-throw contact must be adjustable, you can cut waste and assure uniformity with a General Electric process timer. Total time cycles, ranging from 10 seconds to 8 hours, are set during manufacture. Percentage of "on" time can be varied by user. Pipe nipple simplifies mounting in any convenient knockout, and flexible color-coded leads facilitate wiring. Conduit arrangements: single pole, double throw. Size: 5 in. in diameter, 3¼ in. deep. Operates at 25, 50 or 60 cycles, 120 volts or 240 volts. For full description, see Bulletin GEC-525.



Packaged G-E Speed Variator Reduces Installation Expense

The packaged G-E Speed Variator (a-c powered) is customed-engineered for your applications and fulfills all the requirements of a quality Ward-Leonard drive.

Experienced G-E engineers apply the wide variety of Speed Variator features to your particular problems. You get a compact, adjustable speed drive co-ordinated, assembled, packaged, and completely tested in our factory to your requirements, thus reducing your installation costs.

General Electric's Speed Variator gives you all the benefits of increased machine versatility PLUS the dependability of a customed-engineered packaged adjustable speed system. For complete information, check Bulletin GEA-5335.

General Electric Company
Apparatus Sales Division, Sec. C668-113
Schenectady 5, N. Y.

Please send me the following bulletins:

√ for reference purposes X for immediate project

- ☐ GEA-5921 Photoelectric Relays
- ☐ GEA-5893 Resistance Sensitive Relays
- ☐ GEA-4053 Amplidynes
- ☐ GEA-6091 Unit-cooled D-c Motors
- ☐ GEA-5335 Speed Variator
- ☐ GEC-525 Process Timer

CONSULT YOUR SWEET'S PRODUCT DESIGN FILE!

You'll find "everything electric" for machinery manufacturers in the General Electric Section.

NAME .....

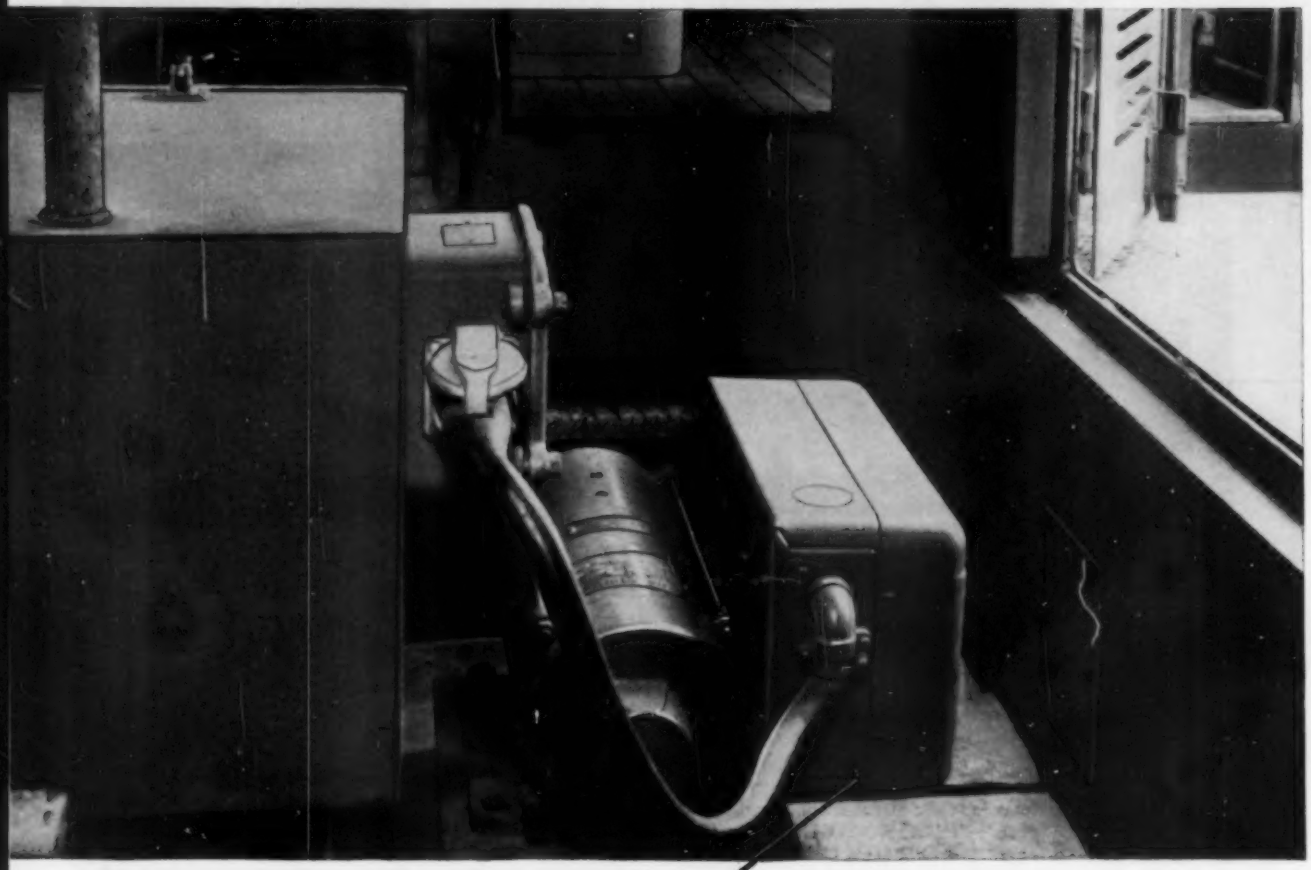
COMPANY .....

STREET .....

CITY ..... STATE .....

The Erie Railroad story shows why it pays to . . .

Get motor application

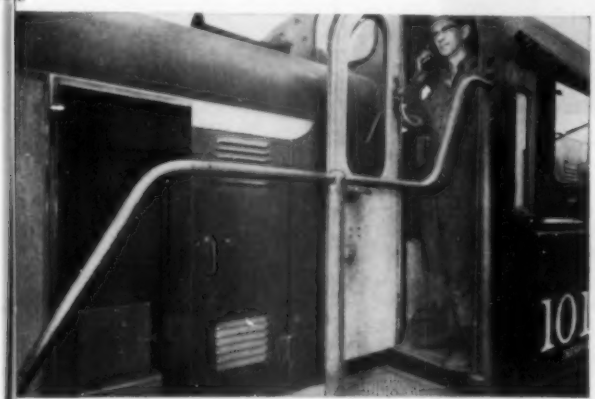


THE ERIE RAILROAD REQUIRED motor alternators to provide 115-volt, 60-cycle power for communication equipment between diesel-electric engines, cabooses, and control stations. The railroad had been using a 64-volt battery system. Illustrations (above) show the G-E designed motor alternator—chosen after competitive tests—and location in the engine. At right, is a brief story of how G-E engineers met the rigid specifications and solved the Erie Railroad's particular problem.

help from G-E Engineers

PROBLEM WAS PRESENTED to G-E sales engineer. Erie Railroad required maintenance-free operation for 3 month periods and a design that would make all servicing feasible except rewinding.

G-E ENGINEERS at the Specialty Component Motor Department in Fort Wayne, Indiana, designed a special open construction type of motor alternator to meet the railroad's precise specifications.



RUGGED TESTS were given this G-E motor alternator on a switcher in railroad's Marion, Ohio, yard. The design struck a happy medium as to design and service, now used on 75 passenger and yard diesels.

PROBLEMS of motor design and motor application are being solved daily at General Electric's Specialty Component Motor Department in Fort Wayne, Indiana. The accumulated engineering experience—unmatched anywhere—starts working for you when you bring your tough motor application problems to General Electric.

THE ERIE RAILROAD had the problem of providing a dependable power supply for their communications equipment mounted on diesel-electric passenger locomotives, switchers and cabooses. They established their needs as a motor-alternator set supplying 115-volt, 60-cycle current. Close voltage control was necessary to insure satisfactory radio tube operation.

WITH THESE REQUIREMENTS in mind, General Electric designed a 2-unit 2-bearing motor alternator which proved the merit and effectiveness of G-E application help in rugged competitive tests.

WHEN YOU HAVE a tough motor application problem, take it to General Electric. Take advantage of G-E engineering skill and talent backed by years of experience. Contact your nearby General Electric Apparatus Sales Office. General Electric Co., Schenectady 5, N. Y. 704-21

You can put your confidence in—

GENERAL ELECTRIC

APPLICATION HELP provided by G-E engineers in solving the Erie Railroad's problem typifies the many cases where design engineers have found it pays to take motor application problems to G.E.

"HOW MANY POUNDS IN A STAINLESS SHEET?"

When sheets are ordered by gauge number, permissible A.I.S.I. thickness variation is plus or minus 10%. Thus, if you order standard 18 gauge 36"x120" stainless sheets you may receive .052" thickness—while your job might actually require about .0475". And in the matter of weight, the theoretical weight of this same standard sheet is 63.00 pounds—but it may permissibly vary between 59.22 and 65.52 pounds. Remember, you purchase sheets *by weight.*

MicroRold Stainless may be ordered rolled to the "light side" of the gauge range. MicroRold Stainless may be held within a 3% tolerance—with such micro-accuracy that you are assured constant uniformity throughout your sheet or strip. And since each one-thousandth inch saved in thickness saves 1.26 pounds per sheet, MicroRold's amazing thinness control may well save you money.

Ask your steel warehouse distributor about MicroRold Stainless.

Washington Steel CORPORATION

WASHINGTON, PENNSYLVANIA

Perspectives ~ DESIGN AND DEVELOPMENT

ATOM DONS CIVVIES

For the first time, the Atomic Energy Commission has planned a long term civilian-sided atomic energy program, aimed at creating economically feasible power plants. Previous efforts have been haphazard, with some progress reported here, a little more there. But now the Joint Congressional Committee on Atomic Energy has pressured the AEC into preparing a formal program that will cover studies for the next five years.

The five year study plan is what many atomic scientists have been urging for years. The size and context of AEC's proposal hint that economical power generation from nuclear piles may be a lot closer than many people have suspected *(Product Engineering,* Feb. 1953, p. 113). Previous minimum discussed by utility engineers was usually 10 years; now, AEC insiders say it will be a lot sooner.

PEACEFUL PROGRAM

As the core of the new program, AEC will build five different reactors, studying the characteristics of each as well as the costs.

It may be that none of the five will be economically competitive for industrial power production. But AEC technicians believe that sufficient reactor technology will be developed to justify the multi-million dollar program.

At the same time, the commission is ready to award a lump-sum contract for the development of a small nuclear power plant, suitable for furnishing electricity at an Army post. Typical specifications for this joint Army-AEC venture: (1) a package unit built in the U. S. but easily assembled and put into operation at overseas installations; (2) a setup that can be moved from one place to another without serious restrictions; (3) a power plant that the Army can afford.

THE PROJECTS

But most attention will be centered on AEC's five experimental power reactors. The projects:

Construction and operation of a giant 60,000 kw pressurized water reactor, to cost about $45 million. This unit will not produce competitive commercial power, because of the extremely high capital cost. But it is already on the drawing boards at Westinghouse Electric Corporation's Atomic Energy Division, and is scheduled for completion within the next four years.

Construction and operation of a breeder reactor of intermediate size. In such a unit, nonfissionable uranium is converted to fissionable fuel at the same time that power is generated. Electrical output of this particular one should be in the neighborhood of 15,000 kw. AEC scientists plan to use liquid sodium to carry the reactor heat to a heat exchanger where it will

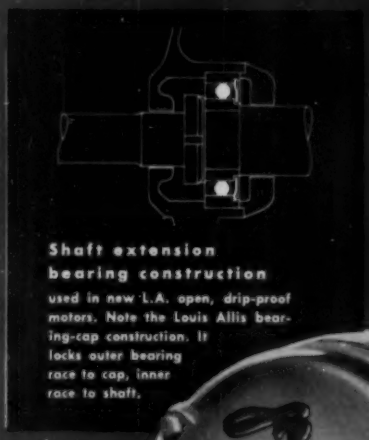
(Continued on page 125)

Here's another reason why

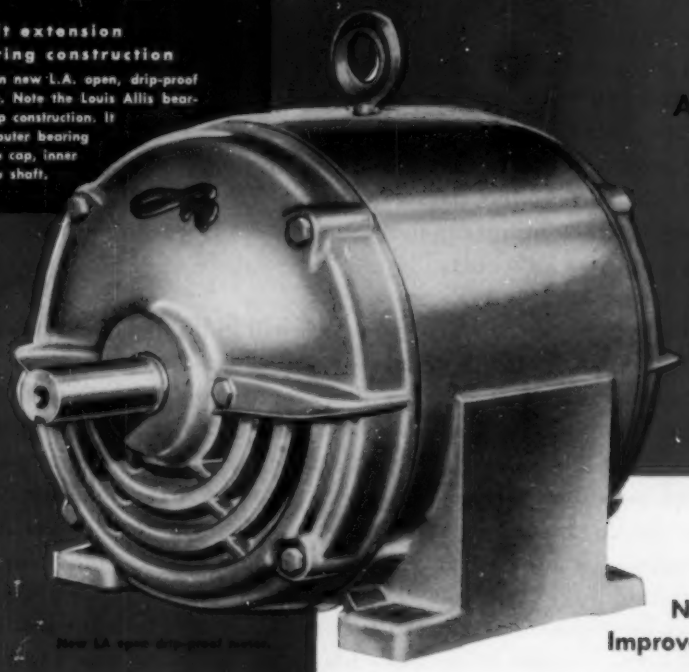
the NEW L.A. *Line*

by the Louis Allis Co.

is your BEST *electric motor* BUY



Shaft extension bearing construction used in new L.A. open, drip-proof motors. Note the Louis Allis bearing-cap construction. It locks outer bearing race to cap, inner race to shaft.



New LA open drip-proof motor

A brand-new power package, completely redesigned inside and out

with NEW BEARING CONSTRUCTION

plus

New modern styling
More compact design
New conduit box arrangement
Improved ventilation and better protection
More versatile mounting

HERE'S the locked bearing construction that makes the new L.A. motors even better—gives them extra life, extra dependability. It positions the rotor . . . limits shaft end-play . . . gives you ample V-belt drive capacity. You get factory prelubrication, too, with a new, improved grease-retaining system that saves servicing and maintenance — for years of attention-free operation under most conditions.

That's not all! You get standard bearings in every unit — sizes specially selected to be easily obtainable from local stocks. And there's no need to tear the motor down to get bearing numbers — they're stamped right on the new motor nameplate.

Add this modern, dependable bearing construction to all the other features and you see why the L.A. line is your best motor buy. Get the complete story from your nearby Louis Allis Sales Engineer.

We specialize in
SPECIAL MOTORS *and*
PROMPT DELIVERY, TOO

There's a Louis Allis special motor for your toughest application. Whatever electrical or mechanical modifications you need check first with Louis Allis.

Vertical NEMA C-flange motor

NEMA D-flange motor

NEMA C-flange motor

THE LOUIS ALLIS CO.
MILWAUKEE 7, WISCONSIN

LA-105

generate steam for a conventional turbine-generator set. Here too, observers don't expect the unit to compete with other sources of energy.

Construction and operation of a boiling water reactor with a power capacity of 5,000 kw. This will be a completely new investigation, so new that technicians are unwilling to hazard a guess as to how economic such a unit will be or what power costs will amount to.

Construction and operation of a homogenous reactor—a scaled-up version of the experimental model now in operation at the Oak Ridge National Laboratories. With this unit too, the economics are unexplored. But engineers think this pile looks more promising for economical production of power than any other underway.

Construction and operation of a sodium-potassium graphite high temperature reactor with a heat capacity of 20,000 kw. Economic factors here are dim and unpromising.

LEGISLATIVE PICTURE

It's no secret that modification of the restrictive McMahon Act (Atomic Energy Act of 1946) is one of the legislative targets of the Eisenhower Administration. Last year, it seemed a sure thing; now most observers think it will have tough going. The major stumbling blocks: private industry's demand for the right to patent ideas originated in atomic energy research, and the question of private industry's right to own and produce fissionable material.

INDUSTRY'S ROLE

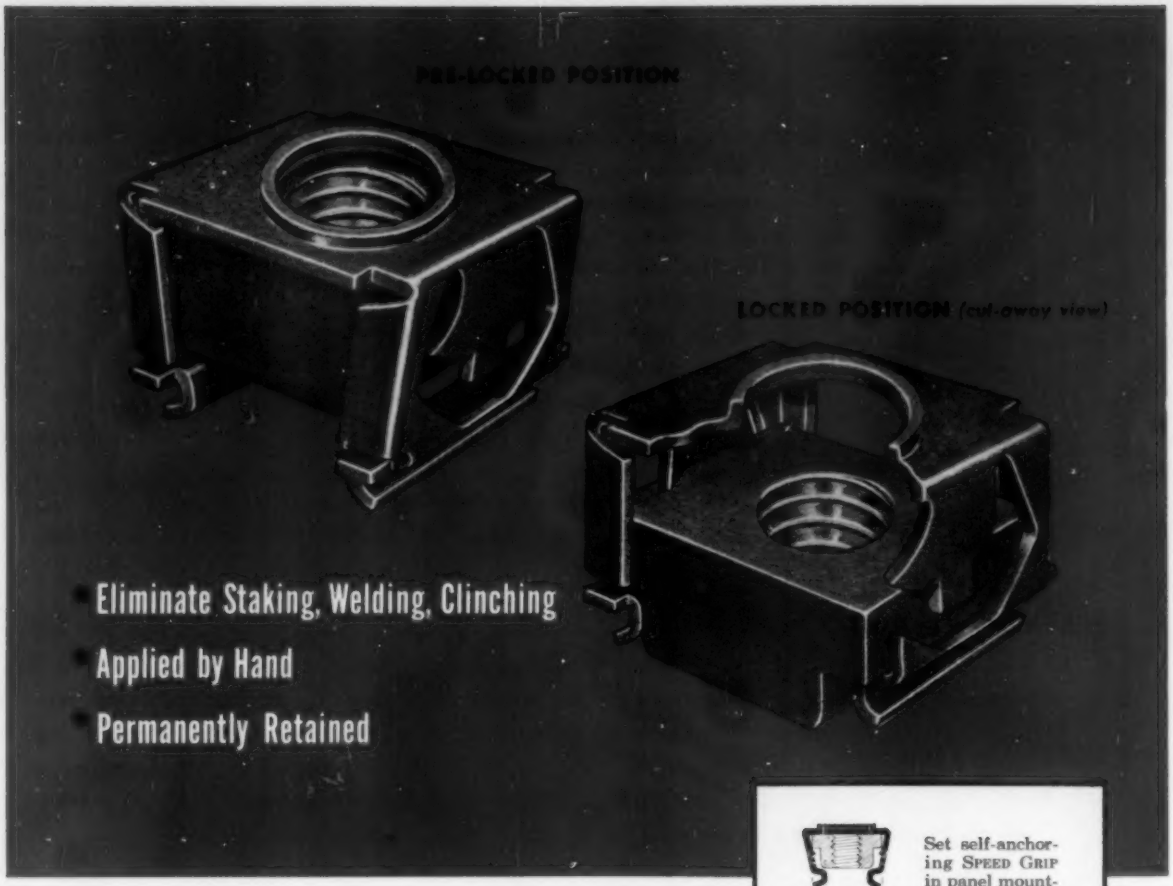
There were two big incentives behind the legislative pressure. Some congressmen wanted AEC to get into power, claiming that private utilities would steal the benefits of the millions the government has poured into atomic research. Other lawmakers felt that putting the government's program down in black and white would permit industry to plan its own research programs accordingly.

Right now, nobody's willing to guess how AEC's program will influence industry. It might increase private participation—and it might decrease it. If an industry group wanted to build a certain type of reactor and found that the government intended to build the same type, the industry people would be likely to step aside. Their argument: Why pour money into a project that the government will pay for?

FOREIGN INFLUENCE

Another reason high ranking government officials were glad to see AEC's power program is that it will probably improve our foreign relations. Most foreign nations that supply sizeable portions of the raw materials for the U. S. Atomic energy program desperately need new sources of power. They have been waiting—not so patiently—for the U. S. to share some of its nuclear power technology.

Belgium, for instance, has openly threatened to choke off U. S. supplies of uranium from rich Congo deposits unless it receives access to power reactor information. Just when the present agreements for Belgium Congo ore expire, nobody seems to know. But it's certain that the agreement will not be renewed unless the U. S. is willing to trade some useful data.

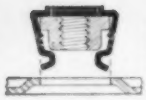


New, Self-Anchoring **SPEED GRIP**®

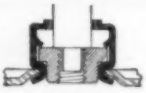
cuts assembly costs in half!

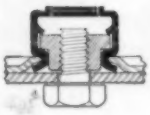
Whatever your present method of attaching square nuts to panels, new self-anchoring SPEED GRIPS can do the job faster, easier, better. This unique fastener has spring steel "mechanical hands" that permanently lock the nut in bolt-receiving position. It cannot be dislodged even with rough handling. Applied after painting or porcelainizing, there is no clogging, retapping or masking of threads to bother about. *And* it is ideal for blind location attachments.

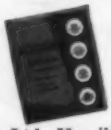
Total up the savings in application time—in expensive assembly equipment—in handling time—in assembly steps—and you'll switch to self-anchoring SPEED GRIPS—the newest addition to the complete Tinnerman line of Nut Retainers.


Set self-anchoring SPEED GRIP in panel mounting hole.

Simple tool presses nut into locked position.




Heavy duty nut in locked position — permanently retained — can't rotate, rattle or be dislodged.


Write today for free copy of new detailed SPEED GRIP Bulletin, No. 335. Tinnerman Products, Inc., Dept. 12, Box 6688, Cleveland 1, Ohio. *In Canada:* Dominion Fasteners Ltd., Hamilton, Ontario. *In Great Britain:* Simmonds Aerocessories, Ltd., Treforest, Wales. *In France:* Aerocessoires Simmonds, S.A., 7 rue Henri Barbusse, Levallois (Seine).

Budgets for Engineering

THE SALES VALUE of a product reflects the quality and quantity of engineering that has gone into it. If the product has been over engineered it may possess the desired qualities but its price tag might be too high. If the product has been under engineered, either quantitatively or qualitatively, it will have limited sales appeal and again the price will be too high. Proper engineering requires both talent and man power.

There can never be a universal formula for determining proper engineering costs. Products for the mass market will naturally have a low engineering cost on the basis of per cent of total sales. A machine that must be designed to fit each application will be relatively expensive to design when the cost is expressed on a percentage basis. Fifteen percent might be low for such a product and excessively high for a mass produced article.

Even after a company has established a reasonable figure for engineering costs, time will call for a change in the figure, always an increase. Some companies are still working on pre-war engineering budgets, but the successful and growing companies now spend much more to keep abreast in their product designs.

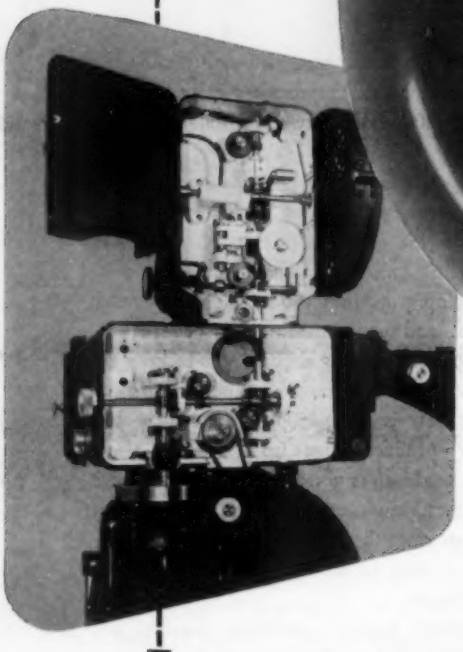
Twenty-five years ago there were relatively few different plastics materials. There was little to choose from in electronic devices, servo units, high temperature alloys and many other classes of items. Fluid couplings, torque converters, hydraulic units and pneumatic controls were in their infancy. Analog computers had not yet been talked about in the daily press. Powder pressings were laboratory novelties and the investment casting process was just getting ready to migrate from dentistry and jewelry manufacture into industry.

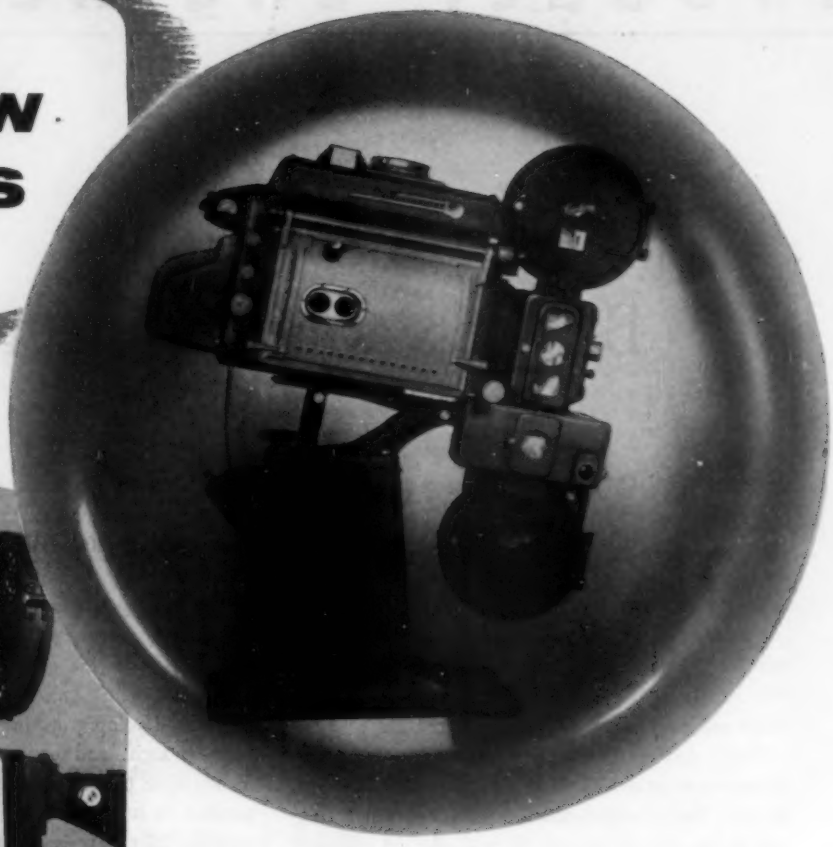
Too many people look back with amazement upon the dizzying pace at which new developments were introduced over the past two decades. They do not realize that the pace has not slackened. To incorporate the new developments into products requires much time, thought and experimenting. Hence the demands upon the engineering departments to keep the product in tune with progress have been increasing rapidly. Not only is more engineering man power needed to keep product designs up to date, but also a much higher grade of engineering talents. Today it takes much more engineering knowledge and gray matter to create even the relatively simple new products. This fact must be reflected in the engineering department budget.

The automobile engine, converting gasoline into power, is like the factory that converts the creations of engineers into products. And just as a modern automobile cannot be run satisfactorily on 1930 gasoline, the modern factory cannot produce profitably on a 1930 engineering budget. We must think realisticly about engineering costs.

George F. Jordenkoff

THE SHOW GOES ON!

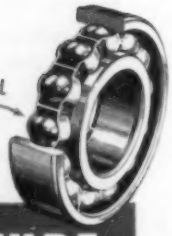




Rear view of Century's Model C Projector Mechanism and Model R6 Sound Reproducer shows location of 14 New Departure **ball** bearings. Century is said to be the first projector manufacturer to use ball bearings with such success.

...ON NEW DEPARTURES

NOTHING ROLLS LIKE A BALL



Fifteen years of operation—*without service of any kind!* That's the record *New Departures* have achieved in Century projectors. Used throughout the world—under all conditions—Century equipment must have long-life, service-free bearings.

Working with Century, New Departure engineers recommended Lubricated-for-Life ball bearings. These bearings seal lubricant in, dirt out . . . preserve alignment of moving parts.

New Departure **ball** bearings can improve *your* product. Talk with New Departure . . . soon.

NEW DEPARTURE
BALL BEARINGS

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT
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Effects of Size on Gear Design Calculations

How scale effects influence center distance, accuracy of angular transmission, and contact ratio in very fine pitch gearing. For each of these factors, methods of designing to minimize them are presented and discussed.

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A MACHINE ELEMENT of given capacity may be enlarged or reduced proportionally in all of its dimensions to achieve a new component of different size and capacity. This approach, design by similitude, frequently is used in the design of gearing because most of the tooth proportions and all of the angles remain the same for all pitches of gearing of any given number of teeth. Since most of the formulas, tables, and curves pertaining to gear design apply to a gear of one diametral pitch, sometimes called the unit gear, the design can be carried out as a one diametral pitch unit, and after the tooth proportions are established, the appropriate values can be divided by the diametral pitch of the gearing required.

However, in the case of pinions with less than about 15 teeth or in diametral pitches finer than about 64, this approach involves considerable risk, particularly if dimensions are subsequently given tolerances for machining purposes. A machining tolerance may produce an effect on operation—called the "scale effect"—that is out of all proportion to the size of the tolerance.

Strict adherence to existing gear design standards does not alleviate the situation since the tolerances are usually applied after the basic design has been established.

Tolerances That Create Scale-Effects

There are three major groups of tolerances, Table I, that contribute to the scale-effect. These are tolerances on center distance, blank dimensions, and tooth dimensions. They may produce tooth interference, error in the transmission of angular motion, rough running gears having too low a contact ratio, or gearing of inadequate strength.

In the first grouping in Table I are not only the tolerances on distance between bearing centers, but also the tolerances introduced by the bearings, some of which support the pinion and others the gear. In some cases, these tolerances accumulate on assembly.

In the second grouping, the most important tolerances—at least in the case of spur and helical gears—are those on the outside diameter. When "topping" cutters are not used, the

Table I—Scale Effects Resulting From Manufacturing Tolerances

	Manufacturing Tolerance	Specific Effect	General Effect
Tolerances on Mounting Distance	On center of bores that locate the bearings supporting the shafts and gears.	(a) Tolerances permitting increase over nominal center distance introduce backlash and loss of contact ratio. (b) Tolerances permitting decrease under nominal center distance produce tooth interference or binding.	The net buildup of these tolerances effects the center distance. If the total is too large, there may be excessive backlash or the gearing may run rough or "ratchety"; if too small, the gearing may bind and run unevenly.
	Fit of shafts within bearings and bearings within bores.	(c) Clearance causes increase in center distance. See (a) above.	
	Within bearings.		
Tolerances on Gear Blank	On size of outside diameter (top lands) of gear blank.	(d) If tolerances permit outside diameters larger than nominal, tip interference may occur with the mating gear. (e) If tolerances permit outside diameter to become too small, a loss of contact ratio may occur.	May result in gearing that does not run smoothly.
	On runout of outside diameter of gear blank.	(f) May cause loss of contact ratio at one point and tip interference at another on one gear; a combination of (d) and (e) above.	Results in gearing that does not transmit angular motion smoothly and are noisy at high speeds.
	Of bore and shaft, to establish fit of blank on shaft.	(g) If too loose a fit, set screws or keys used to fasten gear may hold gear eccentric causing difficulties under (f) above.	
Tolerances on Gear Teeth	On concentricity of pitch circle with bore axis	(h) If excessive, will cause errors in the transmission of angular motion.	Results in gearing that transmits angular motion unevenly. This may cause noisy, rough operation at high speeds.
	On tooth thickness.	(i) If teeth are too thin, excessive backlash and errors in transmission of angular motion will occur. (j) Undersize teeth are produced by feeding cutter to too great a depth. This results in undercut teeth, loss of strength, or excessive backlash.	

tolerances on size as well as on concentricity are important. These have an effect on contact ratio if they result in a gear with too small an outside radius.

In the third group are tolerances that govern the running qualities of the gears: backlash, accuracy of angular transmission of motion, and noise. Tooth thickness and concentricity are the most important.

To properly analyze the scale-effects on a design, the designer should establish the machine tolerances that result from the machine practices used in his shop. Most manufacturing processes are subject to two types of errors: the first is brought about by imperfections within the gear cutting machine itself, which in gearing manifests itself as runout, tooth-to-tooth errors, profile errors, and variations in size from one part to the next in a given batch of parts. The second type of error is due to the inability of the machine operator to set a machine to cut to an exact size; this results in variance in the size of parts from one batch to another. To these may be added errors of measurement that occur during inspection.

These variations are inherent in all machining processes and are, in general, reasonably constant for any given machine tool. As a result, a small part produced on a particular machine will have errors of about the same magnitude as those found in a large part produced on the same machine. For example, the angular spacing error in a gear will be about the same for the small as the large gear, since the same index gear is used for both. The runout or concentricity will be about the same for both, since the same spindles and centers are used. The size variations will also be similar since it is about as easy for the operator to con-

trol depth on a small gear as on a large one. The net result is that the smaller gear will vary from the nominal in all of its dimensions a far greater amount in proportion to its size than will a larger gear made to the same tolerances.

Of course, different levels of operator skill and the methods of handling parts can result in wide differences in product quality. If better data is not available Tables II and III will provide data that can be used to determine the scale-effects in most designs. These values should be modified whenever they do not represent conditions in the shop where the parts are to be produced.

The tolerances on tooth thickness in Table III are divided into two groups. The first is for use when an adjustment can be made at assembly to compensate for size variations in both the gears and their mountings. Frequently the gear is made with a nominal tooth thickness, and half the tolerance is taken on each side of nominal.

The second group of tolerances, for gears mounted on fixed centers, is for use when the gears are mounted on bored centers. In this case the nominal tooth thickness or the center distance should be adjusted to compensate for the errors inherent in the gear. Usually this tolerance is specified as minus except in the cases of pinions with small numbers of teeth. These tolerances lead to scale-effects particularly in the cases of the commercial classes of gears. In the case of a very fine pitch pinion, a reduction in tooth thickness of 0.004 in. for tooth thickness and an allowance of 0.006 in. for total composite error ($0.004 + 0.006 \times 2 \tan 20 \text{ deg} = 0.0085$ in.) is a large percent of the total circular tooth thickness (0.0158 in.) of a 100 diametral pitch gear. It can be reasonably concluded that satisfactory gearing of 64 diametral pitch or finer cannot be made to commercial 1 or 2 classes because of these tolerances.

Influence at Center Distance on Contact Ratio and Backlash

Calculations to determine the magnitude of scale-effects on contact ratio and backlash require a knowledge of the minimum and maximum center distance at which the gears may be expected to operate.

Generally, the maximum and the minimum probable center distance at which the gears may be operated is established by using the root-mean-square of all of the tolerances on the machine surfaces that combine to make up the center distance. In the simplest cases, where the gears are held between two plates, the maximum and the minimum center distances are made up of tolerances on (1) the center distance between the bores that locate the bearings supporting the shafts, and (2) the eccentricity and radial looseness within the bearings.

In some designs, the center distance is determined by a large number of machined surfaces. Such a case is shown in Fig. 1, which is a cross section of an aircraft actuator. This assembly, although not necessarily typical, represents a good example for analysis of center distances in a complex assembly (see Table IV).

The lettered columns in this table show the following: (A) the item; (B) the tolerance, usually on a diameter; (C) the plus or minus amount the tolerance can contribute to center distance (D) the square of the tolerance contributing to the minimum center distance; and (E) the square of the tolerance contributing to the maximum center distance. The values in columns (D) and (E) are added algebraically and their sums shown below the columns. Below these are the square roots of the sums, which are the probable variations from nominal center distance (+0.0021,—0.0019).

The tolerances and the resulting center distances are not unreasonable for gears of 24 diametral pitch. A 100 diametral pitch pinion would cause serious trouble, however. If its tooth thickness and outside diameter were adjusted to accommodate the minimum center distance, it would be running at a low contact ratio at maximum center distance. Its working tooth height is only 0.020 inch. A 0.004 in. variation from one assembly to the next would represent a change equal to

Table II—Tolerances on Fine Pitch Gearing

Class of Gear		Total Composite Error, in.	Tooth-to-Tooth Composite Error, in.
Commercial	1	0.006	0.002
	2	0.004	0.0015
	3	0.002	0.001
	4	0.0015	0.0007
Precision	1	0.001	0.0004
	2	0.0005	0.0003
	3	0.00025	0.0002

Data taken from ASA B6.11—1951

Table III—Suggested Tolerances on Tooth Thickness for Fine Pitch Gearing

Class of Gear		Tolerance on Tooth Thickness, in.		
		Gears Mounted on Adjustable Centers		Gears Mounted on Fixed Centers*
		20 through 48 diametral pitch	49 diametral pitch and finer	
Commercial	1	0.005	0.002	0.0044
	2	0.004	0.002	0.0024
	3	0.004	0.002	0.0018
	4	0.003	0.002	0.0008
Precision	1	0.003	0.001	0.0004
	2	0.002	0.001	0.0003
	3	0.002	0.001	0.0002

* These values will result in variations in backlash as shown in Fig. 2.

20 percent of the tooth height, a serious matter with fine pitch pinions containing low numbers of teeth.

There are several things about this example that are worthy of note.

(a). Most bearing catalogs indicate bearing and shaft tolerances that produce an interference fit. This fit cannot contribute to the maximum or minimum center distance between gearing.

(b). These catalogs also indicate a tolerance on runout between the bore and the raceway of the inner ring, and this eccentricity contributes to the instantaneous center distance when the inner face is the moving portion of the bearing.

(c). Radial clearance between the inner and the outer bearing races usually acts to allow an increase in the center distance due to the reaction between the two meshing gears.

(d). Bearing catalogs indicate a tolerance on runout between the raceway and the outer diameter of the outer ring. This eccentricity contributes to the center distance at which the gears will operate.

(e). These catalogs also indicate a bore tolerance on the hole into which the bearing is fitted. Usually, the tolerance will provide clearance between the bearing and housing. When clearance exists, the gear reaction acts to increase the center distance to the limit allowed by the clearance.

(f). Many manufacturers of pilot-mounted motors specify a value of runout between the motor shaft and the pilot surface. It is customary to measure this by holding the motor shaft fixed (as between centers) and rotating the motor about its shaft. A dial indicator running on this surface will show the runout (twice eccentricity).

(g). A clearance fit is usually specified on the hole into which the pilot of the motor is to fit. This clearance allows the motor to be shifted somewhat and as a result has a direct effect on center distance. The value shown assumes a tolerance of +0.0005 and −0.0000 in. on the bore and of +0.000 to −0.002 in. on the diameter of the pilot on the motor.

(h). In an assembly such as Fig. 1, a tolerance must be placed on the location of the bore to receive the motor relative to the rabbet on the end-plate. This, in effect, is the same type of tolerance as discussed under item (g) above.

(i). Usual drafting practice is to specify a tolerance on the concentricity of the several cylindrical surfaces of a shaft. If these are all machined during one "set-up", they will have little or no eccentricity relative to each other, but this is not always possible.

If the designer wishes to reduce the spread between maximum and minimum backlash, three courses are open. First, the center distance may be made adjustable so that the gears can be moved until the desired mesh is obtained. This entails a method of moving the parts through small distances, and then being able to fix them securely when the desired distance has been reached. This method has an advantage in that it offers a means of eliminating the effects of tolerances both on the size of the teeth and on the distance between gear centers. The scale-effects of these tolerances are, therefore, non-existent in this type of design.

The second alternative is to use fixed centers but to closely control part tolerances. This may be done by selective assembly or by highly refined machining practice, and is preferred for gearing where service under adverse conditions is expected and where simplicity of design is required, since long trains of gearing do not lend themselves well to adjustable center construction.

The third alternative, useful where only small torques are involved, is to use split (scissor) gearing. Such gearing eliminates the need for close control of tooth thickness or center distance, but cannot be used to transmit large torques.

Influence of Scale Effect on Accuracy of Angular Transmission

The success of a fine pitch gear train for instrument applications is usually determined on the basis of its ability to transmit angular motion accurately and to transmit power without undue vibration, or to a combination of both.

Accurate transmission of angular motion may be further classified into two typical situations. First, the gearing may be required to operate with an absolute minimum of lost motion, the actual angular position of the driving and the driven member at any one instant not being of importance. An example of this is the tuning drive in a radio set. Here the actual angular relationship, at any one instant, between the hand knob and the dial is not important, but any backlash between the knob and dial is intolerable. Second, the gearing may be required to transmit angular motion with great accuracy. Examples of this are mechanisms that indicate the position of a gun, rudder or the distance between rolls of a steel mill. If uniform, a small amount of lost motion may be tolerable.

The problem of maintaining an absolute minimum of lost motion is

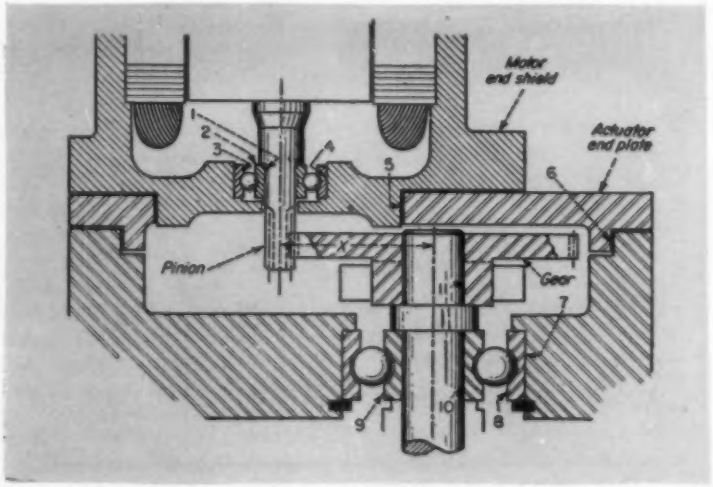


Fig. 1—First stage gearing in an aircraft type actuator. Analysis of the center distance, *X*, between the pinion on the motor shaft and the gear is shown in Table IV.

Table IV—Center Distance Analysis of Actuator Gearing

Item No.	Item	Surface Designation (See Fig. 1)	Tolerance (Clearance) in.	Equivalent Change in Center Distance	Minimum Center Distance Variation	Maximum Center Distance Variation
	Letters, *a*, *b*, *c*, etc, following items refer to the alphabetical listing given on pg 132.	(A)	(B)	(C)	(D) col. $(C)^2 \times 10^{-4}$	(E) col. $(C)^2 \times 10^{-4}$
I	Fit of motor shaft in inner race of ball bearing.....(*a*)	(1)	0.0000	0.0000	0.00	0.00
II	Eccentricity of inner ring of bearing..(*b*)	(1–2)	0.0002	0.0001	−0.01	+0.01
III	Radial clearance in bearing.....(*c*)	(2–3)	0.0004	0.0002	+0.04	+0.04
IV	Eccentricity of outer ring of bearing..(*d*)	(3–4)	0.0004	0.0002	−0.04	+0.04
V	Fit of outer race of bearing into motor end shield.....(*e*)	(4)	0.0008 to 0.0000	0.0004 to 0.0000	0.00	+0.16
VI	Concentricity of axis of bore with axis of rabbet on end shield.....(*f*)	(4–5)	0.0020	0.0010	−1.00	+1.00
VII	Clearance between rabbet of motor end shield and bore of actuator end plate..(*g*)	(5)	0.0025	0.00125	−1.56	+1.56
VIII	Concentricity of motor bore in actuator end plate and rabbet.....(*h*)	(5–6)	0.0010	0.0005	−0.25	+0.25
IX	Distance between axis of gear shaft bore and rabbet in actuator housing.....(*i*)	(6–7)	0.0020	0.0010	−1.00	+1.00
X	Clearance between bore, for bearing and bearing outer race.....(*e*)	(7)	0.0008	0.0004	+0.16	+0.16
XI	Eccentricity, outer race of bearing....(*d*)	(7–8)	0.0004	0.0002	−0.04	+0.04
XII	Radial clearance in bearing.....(*c*)	(8–9)	0.0004 0.0000	0.0002 0.0000	0.00	+0.04
XIII	Eccentricity, inner race of bearing....(*b*)	(9–10)	0.0002	0.0001	−0.01	+0.01
XIV	Fit of gear shaft in bearing race.....(*a*)	(10)	0.0000	0.0000	0.00	0.00
XV	Eccentricity, bearing journal and surface locating gear.....	(10–11)	0.0002	0.0001	−0.01	+0.01
XVI	Fit of gear on shaft.....	(11)	0.0002	0.0001	−0.01	+0.01
				Total ($\times 10^{-4}$)	−3.73	+4.33

Probable value: $\frac{+0.0021 \text{ in.}}{-0.0019 \text{ in.}}$

Note: The maximum and minimum values are based on the assumption that the separating forces between pinion and gear are sufficient to hold the shafts at maximum separation within the limits of the clearance in bearings and their mountings.

usually solved by using "spring-loaded" gears, either split scissor gears or movable "spring-loaded" centers. This type of solution works well if the transmitted load is light and serves to eliminate most of the scale-effect. In many cases, gears of relatively poor accuracy may be used. However, such gearing will not transmit accurate angular motion unless gears of the very highest accuracy are used. It, also, has the further disadvantage of requiring a spring load on each gear tooth greater than the load to be transmitted. This, in turn, necessitates wider or harder gears if tooth wear is to be comparable to gears that are not spring loaded.

If the gears are not spring loaded, the problem of transmitting angular motion with great accuracy requires maximum accuracy on gear size and minimum tooth spacing error. The following discussion covers the major factors to be considered when designing

gear trains to accurately transmit angular motion, and the method of analyzing the requirements and the resultant scale-effects:

1. The accumulated tooth spacing error must be held to a minimum. Accumulated tooth spacing error may be defined as "the maximum accumulation of pitch errors obtained by algebraic addition." In effect, it represents the greatest angular error that any one tooth can have relative to any other tooth on a gear. This error should be measured relative to the journals that locate the gear in its mountings.

2. The thickness of the teeth of the gear must be held to close tolerances if there is no provision for adjusting the center distance at assembly.

3. The center distance must be held to close tolerances if non-adjustable.

4. The bearings that support the gears must be of high quality and be correctly mounted.

The method usually used to calculate the lost motion or accuracy of angular transmission in a fine pitch gear train is based on the assumption that all errors will be manifested in the form of backlash. This simplifies the determination of the magnitude of each of the scale-effects that influences lost motion, and, since each stage of the gear train is evaluated in terms of the last stage, its contribution to the total backlash is readily apparent.

The backlash that can exist at the mesh of any particular pair of AGMA Class of Fine Pitch Gearing operating on various center distances and held to the tolerances shown in Table II and III is plotted in Fig. 2. The backlash is independent of the size of the gears. Scale-effects on the accuracy of angular transmission can make themselves felt as a given value of backlash; a small diameter gear will be able to turn through a larger angle than a large diameter gear when turning within the backlash.

The values of tooth thickness are assumed because no standards have been established for these as yet. The following equations may be used to establish backlash for other combinations of tooth tolerance:

For gears on adjustable centers

$$\Delta B = 4 \tan \phi(E) \qquad (1)$$

For gears on fixed centers

$$\Delta B = 2 \tan \phi[2E + T] + 2t \qquad (2)$$

where E is the total composite error of each gear of a meshing pair, ΔB is the difference between maximum and minimum backlash, ϕ is the operating pressure angle, T is the tolerance on center distance, and t is the tolerance on tooth thickness of each gear of a meshing pair. Thus, the magnitude of backlash that exists between mating gears is a function of the relative tooth thickness and space widths of each of the gears at their operating pitch circles.

The tooth thickness or space width of each gear can be measured in a number of ways, the most popular of which for fine pitch gearing is the rolling check, Fig. 3. The type of chart obtained from this rolling check, Fig. 4, offers a convenient way of describ-

Fig. 2—Relationship between center distance tolerance and backlash spread for meshing, pair of AGMA Class of Fine Pitch Gearing. The figures represent design values of spread of backlash, maximum minus minimum, for any combination of gears made to the tolerance shown.

Fig. 3—Schematic diagram of rolling fixture for checking relative tooth thickness and space width. This device holds a master gear of known proportions and the gear to be measured in tight contact, and indicates or records changes in center distance as the work gear is rotated.

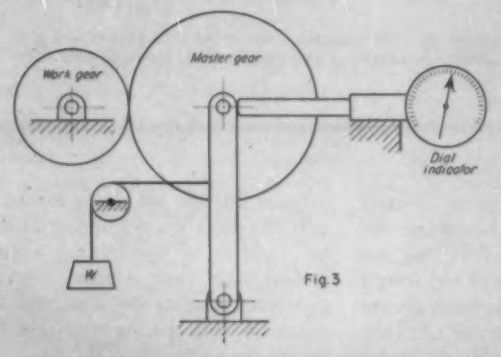


Fig. 3

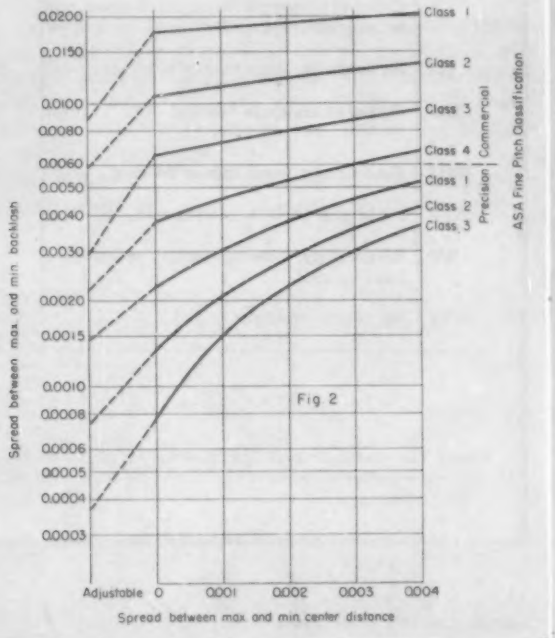


Fig. 4 (Right)—Charts obtained by rolling check of gears mounted on adjustable centers, (A); non-adjustable centers, (B). Chart (C) shows the mesh at maximum center distance tolerance for gears on non-adjustable centers.

ing the problem of evaluating the backlash that results from the combination of tooth thickness tolerance, center distance, and pitch line runout. The charts in Fig. 4(A) represent a gear and pinion that has been brought into mesh and the center distance adjusted at one point so that there is no backlash. The maximum backlash that can theoretically occur is represented by the sum of the total composite tooth errors of the gears (adjusted by 2 tan ϕ). This type of design eliminates the scale-effects of tooth thickness and center distance tolerances, and results in gearing having a minimum of lost motion.

In Fig. 4(B) the tolerance on center distance is assumed to be zero. The wavy lines show the tooth-to-tooth and the total composite errors. The solid horizontal lines show the minimum permissible limits of tooth thickness. These are the limits that apply to any gear of a given design. They represent the sum of the total composite error and the tolerance on tooth thickness adjusted by 2 tan ϕ. The maximum possible backlash in this case is equal to the sum of the total composite errors and tooth thickness tolerances of each of the gears adjusted by 2 tan ϕ.

In Fig. 4(C) the effect of tolerance on center distance is included. The backlash in this case is the same as in Fig. 4(B), plus that resulting from the effect of the center distance tolerance.

As previously mentioned, the first step in calculating the backlash that results from the scale-effects of tooth thickness, concentricity, and center distance is to obtain the backlash in each pair of gears (See Fig. 5). Assume the pitch and numbers of teeth as shown, and obtain the backlash for each mesh from Fig. 2. Then let

Y = shaft to be rotated
Z = shaft to be held fixed
S = speed of Y
G, G', G'' = either member of any pair of gears in the train
B, B', B'' = backlash (in inches) at the pitch line between G and its mating gear.
S, S', S'' = speed of the shaft on which G is mounted
D, D', D'' = pitch diameter of G in inches
θ = angle through which Y can be rotated as a result of the lost motion in the train
c = constant of proportionality

To get θ in radians, $c = 1.0$
To get θ in degrees, $c = 57.296$
To get θ in minutes, $c = 3438$.

$$\theta = cS \sum \frac{B}{\frac{1}{2}D \times S} + \frac{B'}{\frac{1}{2}D' \times S'} + \frac{B''}{\frac{1}{2}D'' \times S''} + \cdots + \cdots \qquad (3)$$

The term "speed" as used above is the velocity of one shaft relative to another. Usually the slowest shaft is assigned the value of 1, and the other shafts geared to this are assigned speeds proportional to their ratios.

Assuming the motor shaft (Z) in Fig. 5 is to be fixed, determine: (a) the amount of lost motion each mesh contributes to the total lost motion at the output shaft (Y); (b) the lost motion (in minutes) at the output shaft; (c) the lost motion at the motor if the output shaft is held fixed.

The equation for backlash is most useful when solved in tabular form as shown below since the amount of lost motion contributed by each mesh is made clearly evident.

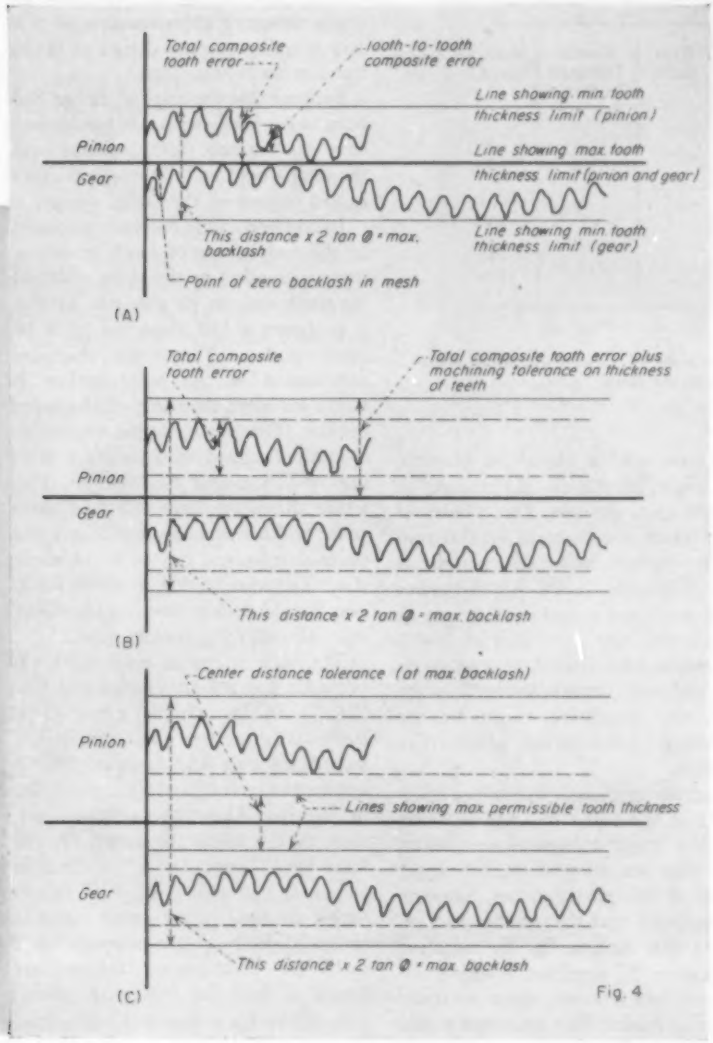
(a)

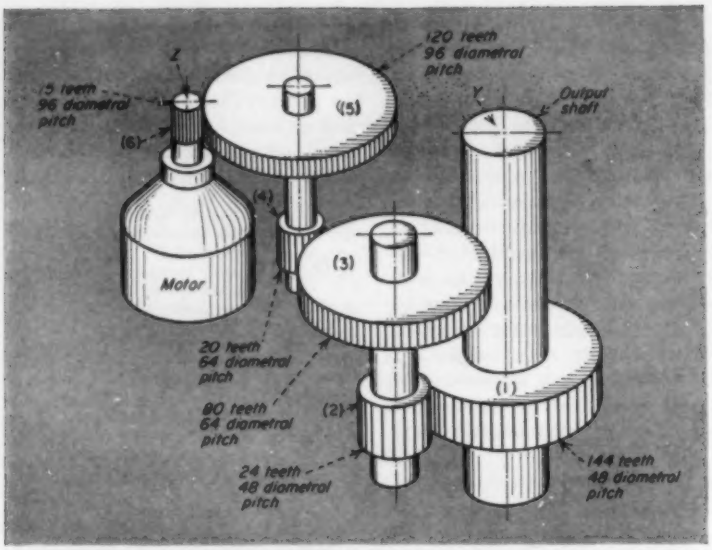
Gear No.	Backlash at Mesh	Pitch Radius	Shaft Speed	$\frac{B}{\frac{1}{2}D \times S}$
1	0.0015	1.50	1	0.0010
3	0.0030	0.625	6	0.0008
5	0.0030	0.625	24	0.0002
Total				0.0020 radians

(b) $0.0020 \times 3438 \times 1 = 7.14$ minutes
(c) $0.0020 \times 3438 \times 192 =$ 1374.0 minutes or 22.85 deg.

Each of the values in the last column above is the amount of lost motion contributed to the single speed shaft by each of the individual gear meshes.

Even though the unit speed (out-


Total composite tooth error
Tooth-to-tooth composite error
Line showing min. tooth thickness limit (pinion)
Pinion
Line showing max. tooth thickness limit (pinion and gear)
Gear
This distance x 2 tan Ø = max. backlash
Line showing min. tooth thickness limit (gear)
Point of zero backlash in mesh
(A)
Total composite tooth error
Total composite tooth error plus machining tolerance on thickness of teeth
Pinion
Gear
This distance x 2 tan Ø = max. backlash
(B)
Center distance tolerance (at max. backlash)
Pinion
Lines showing max. permissible tooth thickness
Gear
This distance x 2 tan Ø = max. backlash
(C)
Fig. 4



Gear Proportions

Gear	No. Teeth	Pitch	Pitch Radius	Backlash at Mesh	Gear Ratio	Center Distance Tolerance	Shaft Speed
1	144	48	1.50	0.0015	6:1	adj.	1S
2	24	48	0.25				6S
3	80	64	0.625	0.0030	4:1	±0.0005	6S
4	20	64	0.1563				24S
5	120	96	0.625	0.0030	8:1	±0.0005	24S
6	15	96	0.078				192S

Fig. 5—Typical fine pitch gear train and proportions of various operating members. See text for method of calculating backlash in the train.

put) mesh was made adjustable, it is still by far the largest contributor to the total backlash in the gear train. Thus, it may be concluded that the motor mesh might even be reduced in accuracy with little increase in the overall lost motion at the output. In this case, the analysis indicates that from the standpoint of backlash, gears of relatively low accuracy may be used.

Several other problems should be considered before the lower class of gearing is specified in the high speed meshes Nos. 3-4 and 5-6. First is the problem of gears running at high pitch line velocities. The AGMA suggests the following classes of Fine Pitch Gearing for different operating speeds in surface fpm.

Up to 80 fpm	Commercial Class 1 or 2
Up to 400 fpm	Commercial Class 3 or 4
Up to 2,000 fpm	Precision Class 1
Over 2,000 fpm	Precision Class 2 or 3

Suppose that in the above example the single revolution shaft were to operate up to 50 rpm. This would require motor speeds up to 10,600 rpm on the motor shaft. The peripheral velocity of the motor pinion under these conditions would be 435 fpm. A Commercial No. 4 or Precision No. 1 gear would be indicated, depending on load and noise considerations. In some cases, this limitation might be the governing consideration rather than backlash.

Another problem is that of the scale-effects of the center distance tolerance and the larger tolerances on contact ratio that are allowed on the lower classes of fine pitch gearing. Suppose, for example, that the gearing had excessive lost motion for the required application. If members 1 and 2 did not carry much power, the gears could be spring loaded. The gear train would then have a theoretical lost motion of 0.00085 + 0.00021 or 0.00106 radians, only 51 percent as much as the previous value.

Another approach would be to make the low speed gear larger, thus reducing the scale-effect. This could be done by using the following ratios: 24/288, 48 pitch; 20/75, 64 pitch; and 15/64, 96 pitch.

The lost motion calculation would appear as follows:

Gear No.	Backlash at Mesh	Pitch Radius	Shaft Speed	$\frac{B}{\frac{1}{2}D \times S}$
1	0.0015	3.00	1	0.000500
3	0.0030	0.586	12	0.000427
5	0.0030	0.3335	45	0.000200

Total = 0.001127 radians
$0.001127 \times 3438 = 3.87$ minutes

Thus, this last design represents an improvement of approximately 50 percent over the original design as far as lost motion is concerned.

Suppose that the original design had been based fixed centers. It would then have contributed 0.002 radians and the total would be 0.003 radians. This is 150 percent of the initial design.

In addition to the backlash produced by the scale-effects of tooth thickness, there is an effect on the point width of the tooth and on its strength. In Fig. 6 is shown a 100 diametral pitch 10 tooth pinion. The tooth thickness represented by the outer outline is 0.002 in. more than that of the inner outline. The outer outline represents a tooth designed in accordance with the ASA Standard B6.7—1950. This figure shows the large effect on tooth point width that is produced by a not unusual tolerance on tooth thickness. Any further reduction in tooth thickness would reduce the outside diameter, thus affecting contact ratio.

The scale effects of tooth thickness on tooth strength are pronounced (see Fig. 7). In this example, a gear of 10 teeth 100 diametral pitch designed in accordance with ASA Standard B6.7 is assumed to have 0, 0.001 in., and 0.002 in. backlash. Only the trochoidal portions of the fillets are shown for the latter two cases. By a construction similar to that shown, the "Y" factors which are used in the Lewis equation to establish the beam strength of a tooth for each tooth thickness are found to have the following values:

1. 0.264 for a standard addendum,

resulting in a theoretical tooth strength of 100 percent.

2. 0.214 for an error of 0.001 in. on tooth thickness, giving a theoretical tooth strength of 81 percent.

3. 0.180 for an error of 0.002 on tooth thickness, resulting in a potential strength of 68 percent.

Thus, each 0.001 in. reduction in tooth thickness lowers pinion strength by approximately 20 percent. Conversely, an increase in thickness—especially in the case of very fine pitch gearing—may cause binding.

Influence of Scale Effect on Outside Diameter

The outside diameter of a gear need not bear a fixed relationship to its number of teeth and pitch. This fact is commonly used to advantage in the design of pinions with small numbers of teeth (to avoid undercut) and of gearing requiring given gear ratios on non-standard center distances. There are two conditions that limit the amount that the outside diameter can be made different than standard. The minimum outside diameter for a gear of given pitch and number of teeth is limited by the diameter of the undercut portion of the tooth, Fig. 8. The maximum outside diameter is limited by the diameter at which the teeth come to a point.

The outside diameters of gears having small numbers of teeth or fine pitches are very susceptible to scale-effects. The ASA Standard B5.11—1950 recommends a series of values for outside diameters for pinions with small numbers of teeth. The dash line in Fig. 9 shows the ASA values recommended to avoid dangerous undercut of pinion teeth. This curve is based on one diametral pitch.

The value ΔD is a term frequently used in the design of fine pitch gearing. It is the difference between the "standard" outside diameter D_o (defined below) and a modified outside diameter.

$$D_o = D + 2 \qquad (4)$$

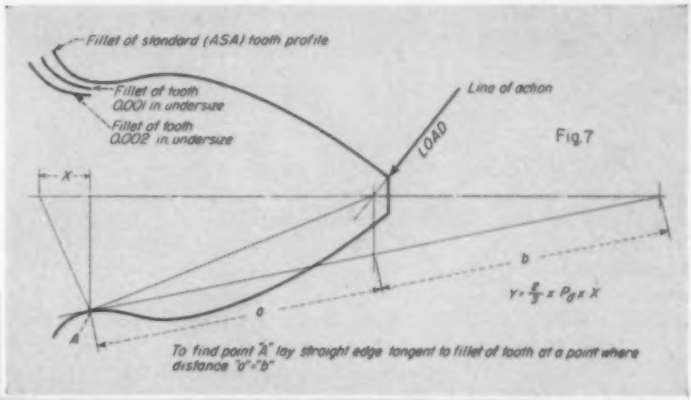
$$D = \frac{N}{Pd} \qquad (5)$$

where N is the number of teeth in the pinion or gear, Pd is the diametral pitch of pinion or gear, D'_o is the outside diameter other than D_o, and ΔD equals D'_o minus D_o.

The Standard previously referred to, ASA B5.11—1950, recommends that the outside diameter of a 15 tooth pinion of one diametral pitch should be 17.2453 in. The standard outside diameter D_o would be 17.00 in. Therefore, ΔD is 17.2453 minus 17.0 or 0.2453. For the 15 tooth motor pinion, Fig. 5, the outside diameter would be 17.2453/96 or 0.1796 in. basic. If this were a precision Class I pinion, its minimum outside diameter at the point of lowest runout, Table V, would be:

$$0.1796 - \left[\frac{0.001}{2} + \frac{0.001}{2}\right] = 0.1786 \text{ inch}$$

The value ΔD is divided by the diametral pitch of the pinion or gear gives the amount in inches that the outside diameter is larger or smaller


Fillet of standard (ASA) tooth profile
Fillet of tooth .0001 in undersize
Fillet of tooth .0002 in undersize
Line of action
LOAD
Fig.7
X
b
a
A
Y = f/p x Pd x X
To find point "A" lay straight edge tangent to fillet of tooth at a point where distance "a"="b"

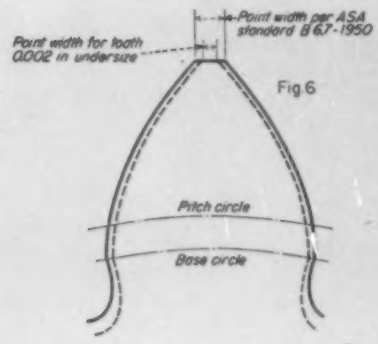


Fig. 6—Effect of tooth thickness tolerance on the point width of a 100 diametral pitch 10 tooth pinion. Dotted line represents a not unusual tolerance on tooth thickness.

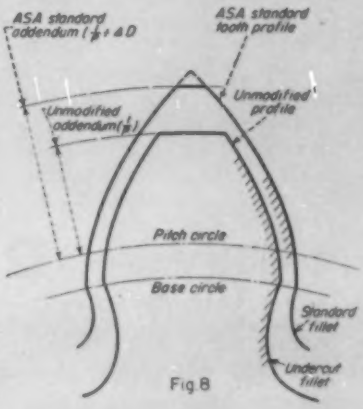
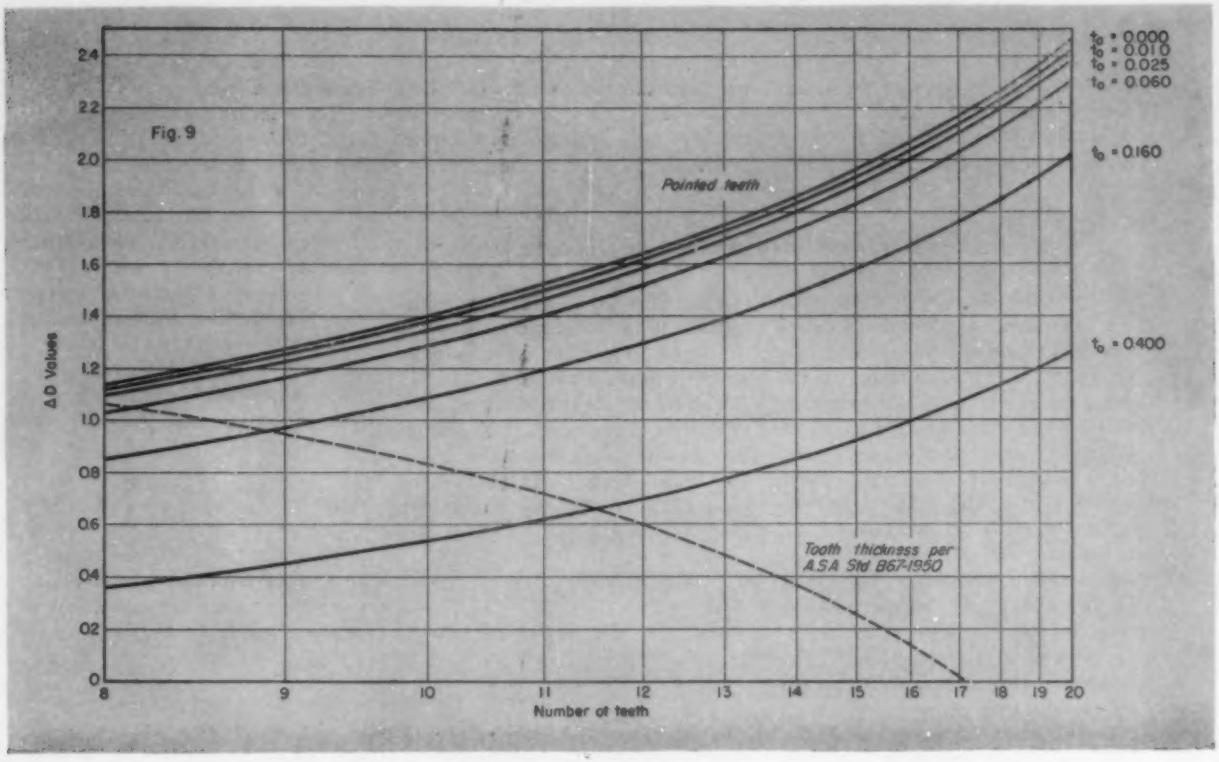


Fig. 7—How scale effects of thickness influence tooth strength by lowering the value of the Y factor in the Lewis equation for beam strength. Each 0.001 in. decrease in tooth thickness lowers the beam strength by approximately 20 percent.

Fig. 8—The minimum outside diameter for a gear of given pitch and number of teeth is limited by the diameter of the undercut portion of the tooth, while the maximum is limited by the diameter at which the teeth come to a point.



than standard. This value, and values of ΔD for all numbers of teeth for pinions having from 8 through 17 teeth, may be found on the curves presented in Fig. 9. As the whole depth of fine pitch gearing is increased or decreased the same amount as the outside diameter in most cases, the value ΔD represents twice the change in center distance at which the gear will operate correctly. Fig. 9 shows the amount of ΔD that may be added to any gear of a given number of teeth in order to achieve (a) pointed teeth, or (b) teeth with specific values of top land.

The outside diameter of a cut gear is produced either by the lathe or screw machine used to produce the gear blank, or by the hob used to cut the teeth if a topping hob is used. Each of these methods involves scale-effects.

Gears cut without topping are subject to the effects of diameter and runout tolerances on the outside diameter, Table V. In the case of fine pitch gearing particularly with small numbers of teeth, these tolerances make the difference between teeth with a definite top land and teeth which come to a point.

The sketch in Fig. 10 shows how the point width of a tooth varies when the outside diameter circle is 0.002 in. oversize and also when this diameter is 0.002 in. undersize. This layout was made for a 10 tooth 100 diametral pitch pinion.

Gears with pointed teeth actually have a lesser outside diameter than the blank from which they were cut. Thus, the gears are subject to detrimental scale-effects as far as the contact ratio is concerned as well as suffering an inherent decrease in tooth load carrying capacity.

Gears cut with topping hobs avoid the scale-effects of the runout and size tolerances on the blanks. These gears are subject to the size tolerance ground into the topping hob. In general, the hob manufacturer desires a tolerance of 0.002 in. or 0.003 in. on the relationship between the part of the hob that produces the top land of the gear tooth and the part that controls the tooth thickness. Thus, two gears of a given tooth thickness cut by two different hobs will show rather serious scale-effects on contact ratio in the very fine pitch range. The amount that a gear tooth can be altered in tooth thickness at the pitch line to obtain a given width at the tip is shown in Fig. 9.

This represents the limiting outside diameter and is of importance on pinions with very small numbers of teeth (10 or less). Here a small change in tooth thickness will make a large change in outside diameter. Thus, the contact ratio, which is already critical, will be greatly affected.

How Scale Effects Influence Contact Ratio

The scale-effects on center distance and on outside diameter of pinion and gear may cause a dangerously low contact ratio. This will manifest itself as rough running gearing. For smooth operation the gear mesh should have a contact ratio of 1.2 or higher in accordance with a recommendation of the American Gear Manufacturing Association. Contact ratio may be defined as the ratio of the base pitch to the effective length of the line of action, Fig. 11. As the center distance is increased or the outside diameters are

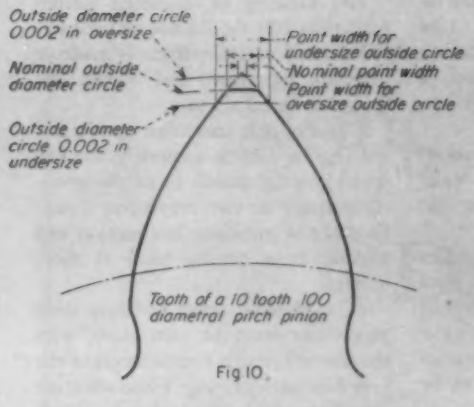
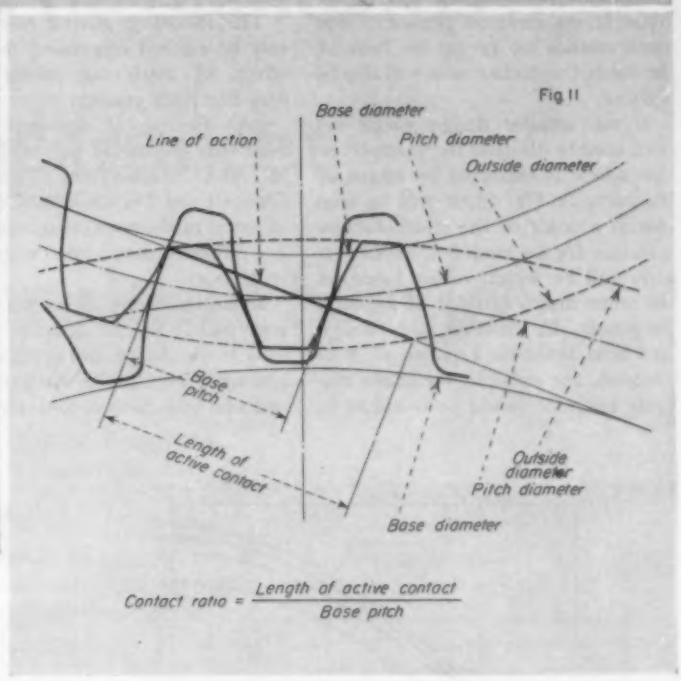

Outside diameter circle 0.002 in oversize
Nominal outside diameter circle
Outside diameter circle 0.002 in undersize
Point width for undersize outside circle
Nominal point width
Point width for oversize outside circle
Tooth of a 10 tooth 100 diametral pitch pinion
Fig 10

Fig. 9—Relationship between $\triangle D$ and thickness of tooth at the tip. The value $\triangle D$ represents twice the change in center distance at which the gear will operate correctly.

Fig. 10—Teeth on gears that are not hobbed at the tip are influenced by the diameter and runout tolerances.

Fig. 11—Base pitch and line of action define contact ratio. As the center distance is increased or the outside diameters are decreased, the effective length of the line of action become shorter, thus reducing the contact ratio.



decreased, the effective length of the line of action becomes shorter, thus reducing the contact ratio. When calculating the minimum contact ratio that is possible for a given pair of gears, the maximum possible center distance and the minimum effective outside radius should be used. The equation is as follows:

$$m_n = 1/p_b \left[\sqrt{(D_o'/2)^2 - (D_b'/2)^2} + \sqrt{(D_o/2)^2 - (D_b/2)^2} - C' \sin \phi_1\right] \quad (6)$$

where m_n is the contact ratio, D_o is the outside diameter of the driving gear, D_o' is the outside diameter of the driven gear, D_b is the base circle diameter of the driving gear, D'_b is the base circle diameter of the driven gear, C_1 is the operating center distance, ϕ_1 is the operating pressure angle, and p_b is $\pi D_b/N$. (7)

The operating pressure angle is obtained from

$$\cos \phi_1 = \frac{C \cos \phi}{C_1} \quad (8)$$

where

C = standard center distance

$$= \frac{N' + N}{2Pd} \quad (9)$$

C_1 = operating center distance

ϕ = standard pressure angle.

Recommended procedure for finding the contact ratio for a gear train can be illustrated by an analysis of the drive shown in Fig. 5.

The standard center distance from Eq (9) will be

$$C = \frac{15 + 120}{96 \times 2} = \frac{135}{192} = 0.703125$$

From the previous analysis made on this gear train the maximum tolerance on operating center distance was found to be 0.0021 in. The maximum operating center distance C_1 is

$$0.703125 + 0.0021 = 0.705225$$

From Eq (8) the operating pressure angle is

$$\cos \phi_1 = \frac{C \cos \phi}{C_1} = \frac{0.703125 \times 0.93969}{0.705225}$$

$$= 0.9368918$$

$$\phi_1 = 20.464° \quad \sin \phi_1 = 0.3496203$$

The base pitch from Table VI is 0.0308. The outside radius is 0.078 in. for the pinion and 0.625 in. for the gear (see above). The contact ratio (m_n) from Eq (6) is

$$m_n = [\sqrt{(0.0893)^2 - (0.0734)^2} + \sqrt{(0.6336)^2 - (0.5873)^2} - 0.705225 \times 0.3496203] + 0.0308$$

$$m_n = 1.31$$

If standard values of outside diameter (nominal) are used, the value of the contact ratio for various numbers of teeth in pinions and gears can be read from Fig. 12. As a convenience in designing fine pitch gearing, special charts for each diametral pitch and pressure angle can be prepared to show the relationship between contact ratio and the number of teeth in the gear and pinion and the center distance at which they operate, Fig. 13. This is very convenient in establishing the scale-effects of center distance on contact ratio. The chart shown is based on outside diameter tolerances on gear and pinion as shown in Table V.

Contact ratio is very sensitive to

scale-effects. It is reduced by an increase in center distance. It may also be reduced by a reduction in the outside diameter of the gear or pinion. This may occur as a result of runout or tolerance on size and may be aggravated by excessive brushing to remove burrs, thus rounding the tips of the teeth. If the undercut portion of the tooth extends too far up the flank of the tooth, the contact ratio will also be reduced.

If the actuator design which has been used to illustrate the examples in this article is examined by means of the curve in Fig. 13, it will be seen that as a result of the center-distance tolerance for the mesh 5-6, the contact ratio will be within reason based on the center distance 0.0021 in. as found previously. If, however, this design had been based on a pinion of 9 or 10 teeth, for example, the center distance tolerance would be found to be too large as shown by Fig. 13. The contact ratio for a 10 tooth pinion operating at a center distance 0.002 in. above nominal is seen to be 1.14 which is dangerously low. In such a case the scale-effects are of such a magnitude as to make the design undesirable.

The following general conclusions may be reached concerning the scale-effects of machining tolerances on very fine pitch gearing.

(A) Gearing of diametral pitches finer than 64 should not be designed to ASA Classification Commercial Classes 1 and 2 unless a study of scale-effects is made, or previous experience has definitely shown the design to be satisfactory.

In general, scale-effects are of concern mostly to the designer who is used to the design and application of gearing larger than 48 diametral pitch and who finds himself confronted with a design requiring extremely small gearing.

(B) Gearing of diametral pitches finer than 100 should not be used unless a study of scale-effects is made or previous experience has shown the design to be satisfactory.

(C) For gear trains that must transmit angular motion accurately, the low speed gearing should be of the greatest accuracy or else provisions should be made to minimize lost motion and angular error of the teeth at these meshes.

(D) Manufacturing and inspection procedures must be compatible with the size and design requirements of the very fine pitch gearing. Close attention must be given to center distances, outside diameter, and tooth size. Such minor details as rounding of tips of gear teeth during burr brushing become important contributions to scale-effects if not closely controlled.

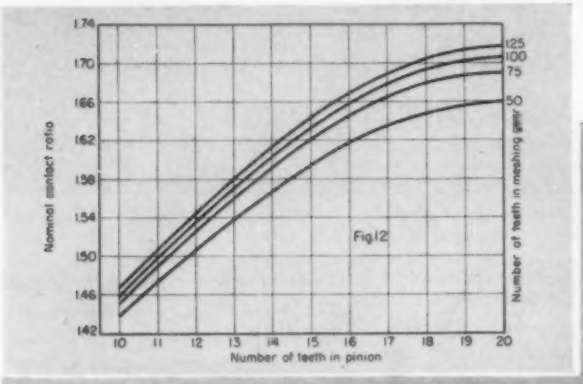


Fig. 12—Contact ratios for various numbers of teeth in pinions and gears, based on standard values of nominal outside diameter.

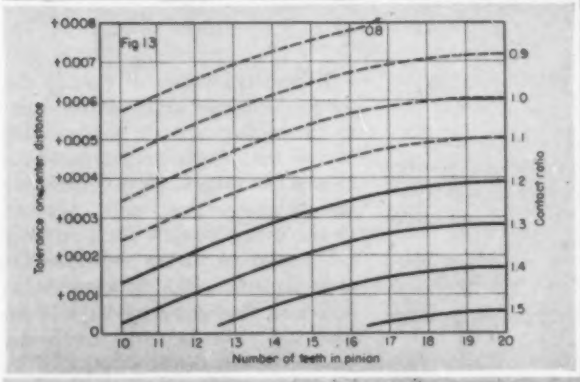


Fig. 13—Special charts, such as the one above, can be prepared to show the relationship between center distance tolerance and contact ratio for each diametral pitch and pressure angle.

Table V—Tolerances on Gear Blank Dimensions

Class	Outside Diameter	
	Size Tolerance in.	Runout Tolerance *
Commercial 1, 2, 3		
20–40 Dia Pitch	+0.000–0.004	0.003
41–80 Diametral Pitch	+0.000–0.003	0.002
81 and Finer Diametral Pitch	+0.000–0.002	0.001
Commercial Class 4 and Precision Classes 1, 2, 3		
20–40 Dia Pitch	+0.000–0.003	0.002
41–80 Dia Pitch	+0.000–0.002	0.0015
81–Finer Dia Pitch	+0.000–0.001	0.001

* (Total Indicator Reading, in.)

Table VI—Base Pitch for Diametral Pitch

Diametral Pitch	Base Pitch, in.	Diametral Pitch, in.	Base Pitch, in.
20	0.1476	48	0.0615
24	0.1229	64	0.0491
32	0.0923	80	0.0369
40	0.0738	96	0.0308

Using The Standards Department As a Consulting Service

ARTHUR KOPPEL
Arma Corporation

The function of the Standards Department in most medium-size companies is often limited to the preparing and maintaining of a Standard Parts Manual. However, several large companies and some smaller ones in specific areas like the electronic component field have found that a well-organized and integrated group of this type can be of valuable service to their design engineers. This stems from the fact that a Standards Engineer is in a position to supply information readily that other engineers would find difficult and time consuming to gather. Specifically, a designer could consult his standards man for technical data or assistance on any of the questions listed below.

1. What Specifications and Codes Are Involved?

If a product is for civilian consumption, then there are both specifications and codes that are fundamental law. Underwriters' codes specify particular safety factors; insurance companies are frequently involved in specifications; and governmental agencies, such as cities, townships, or countries may specify functional characteristics for an appliance.

If the product is for military consumption, the specifications involved can be overwhelming to anyone but a specialist in this field. AN, JAN and MIL specifications for parts, processes, equipment and contractual requirements must be considered.

With both types of products, however, it is desirable to have available a breakdown of the applicable specifications that is complete, down to all minor details. Such a breakdown can be prepared, and issued as a guide to all project and design personnel on a project. It would list all specifications by title, issuing agency, number, and date and therefore represent a fundamental design criterion in that it dictates performance requirements.

These data should also be supplemented with sub-specifications, such as thread sizes and fittings, values of resistance and capacitance, etc. The latter, however, need not be issued with each project, since they are what may be referred to as "standard standards".

One outstanding example of possible trouble in specification interpretation exists in the military codes covering AN connectors, where there are MIL-C-5015, Amendments 1 and 2, as well as the latest version, MIL-C-5015A, which alternately specify an aluminum-cast body without protective finish, with cadmium-plate finish, and with an olive-drab irridite finish of cadmium plate, with further specification requirements on the characteristics of the plastic insert material. All these specifications in themselves are minor

specifications, and part of major equipment specifications. A complicating factor is that MIL-C-5015A may be used in lieu of MIL-C-5015 with its amendments, but does not supersede it at this time and MIL-C-5015B is currently being prepared.

Although specifications in existence at the time of signing of the particular contract are usually applicable, it is often possible to utilize newer versions if it is to the advantage of the product. A still further complicating factor is introduced into this picture by the fact that, under certain circumstances, an equipment manufacturer may wish to use a different connector, say with a black anodized finish, for appearance, non-reflectivity, or for materials reasons. The questions that arise immediately are: Which specification should be followed? Should a waiver for a non-standard finish be obtained? Which plastic insert material is best suited to the application? And, beyond these, there is the problem of what can be obtained on the market commercially and its availability. The answers to these questions might call for a change in planning, or for requesting a waiver of a requirement. And, in the above connector, the question of cadmium plating may lead to various possible actions depending upon materials considerations. These may affect the design and sometimes call for possible changes in the contractural requirements.

Probably only a Standards Engineer would be aware of the fact that, although the above mentioned MIL-C-5015 is a minor part of an equipment specification, it itself references a sub-specification, MIL-P-14, which covers the characteristics of plastic materials. He knows that the requirements of this sub-specification further affect the availability as well as performance of the component part. He becomes a "pipeline" to the vendor of the component part as well as to the issuing agency of the component specification and can solve problems like this, without wasting design man-hours. He is the expert in such matters and can help avoid conflicts with contractural requirements. Thus, when the product is completed, design and manufacturing man-hours have not been diverted by delays, re-design, or even by a simple investigation. The only action required for efficient operation is for the design or project engineer to consult the Standards Engineer on the use of component parts in time, so that the findings can become part of the final design before it reaches the production stage. Such efficiency is, of course, further enhanced by the periodic issuance of bulletins by the Standards Department, as trouble spots become obvious.

2. What Suppliers Are Available?

To provide service to design and project personnel on performance and available of component parts and materials, the Standards Department would maintain a large and up-to-date collection of catalogs and reference books.

It has been found helpful to index catalogs on cards, abstracting the particular item contained. Thus, an index may contain cards labeled "fasteners, blind, quick disconnect", "switches, pressure sensitive, precision", "connectors, rack and panel, miniature", etc., and then list the names of the various companies whose catalogs are on file and who produce the particlar item. For easy location, each catalog might be assigned a serial number, which is also assigned to the particular manufacturer. Thus, a catalog may be located quickly from either the item file or from an alphabetical listing of manufacturers.

The success of such a catalog file is subject to only two governing factors. First, the completeness and accuracy of the indexing and abstracting of the items contained therein, and secondly by the up-to-dateness of the cataloges themselves. It will be found that manufacturers of component parts and materials are only too willing to maintain a Standards Department on a permanent and complete mailing list. Certainly it is more efficient, and therefore more desirable for them to have one central reference file to which they can address all new literature than to distribute these to a variety of personnel throughout a company. They may wish to have a large mailing list, but they also would like to have one complete file established in a given company. As a further aid, the Standards Department would see that a sufficient quantity of each bulletin is received, and, after retaining those for their own files, would distribute the remainder to other interested groups. This does not mean, of course, that engineering personnel should be prohibited from writing for their own copies, but it will be helpful to have an assured central source for all up-to-date information. It is not unheard of to find a designer, in all good faith, use an outdated brochure on component parts or materials. Only when the material was finally purchased, or, possibly only after it was received, was it found that a particular characteristic had been revised. An outline or mounting dimension, or a functional aspect may have been changed by the manufacturer. As a result, the part could not be used without modifying mating parts or a whole assembly. Such mistakes mean delays and increased costs.

Another advantage of maintaining an extensive and up-to-date catalog file is that it broadens the choice of component parts and materials. A designer hardly can be expected to know of all the manufacturers of a particular item. There may be possible variations in one or all of several factors, such as performance, reliability, availability and cost, and design. If restricted to his own resources, the average engineer may be limited to the products of relatively few manufacturers and thus may miss the optimum choice.

A complete catalog and reference file also saves time. A project engineer may wish to know whether a device of particular characteristics is readily available, and what its detailed performance specifications are. He may not necessarily be acquainted with any one particular source for the item. If he had no Standards Department to turn to, he would have to stop his current activities and devote valuable hours to a component search. After he locates possible sources he will have to have lengthy discussions with them to present his problem and discuss the applicability of their particular prod-

ucts. He will then have to consider conducting evaluation tests on these products. And yet, after all of this effort, he may not necessarily have called upon the manufacturer of the device with the best characteristics for his particular application! This would not be a reflection upon the man's ability or resourcefulness. It is rather that he could not possibly be expected to be acquainted with all the possible sources for all the items required in his design. The solution to his problem would be to consult his Standards Engineer, give him the desired performance characteristic of a particular item, and let him supply information regarding possible vendors, including performance and evaluation data on their product as well as information regarding availability and cost.

This catalog service, is further enhanced by a reference file of technical data. By means of this file the Standards Engineer can suggest special devices which will perform in a required fashion, or which can be combined to produce a required result. One example might be the choice of a shock and vibration mounting. A variety of manufacturers exist in this field, making different products, in some instances with different materials. Among them, there are the so-called ruggedized shock mounts, with possibly different finishes. The Standards Engineer can suggest particular items to suit a required need, and can supplement this information with application data. In the case of electrical resistance—capacitance filters, he may, for example, suggest that such a device is not readily available on the market for a particular performance characteristic, and that it is more economical to utilize individual components to achieve the desired result. He may supply data which may aid in quick calculation of the necessary circuit configuration. The reverse may also occur, where a designer may wish to assemble a device, which a Standards Engineer can tell him can be readily bought as a component.

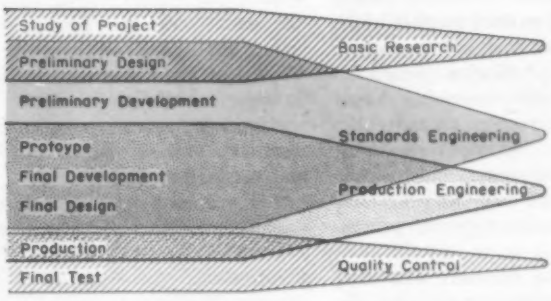
3. Which Component Is Best for a Given Application?

It is obvious that in the course of continuous activity of this type the Standards Engineer accumulates more and more knowledge regarding the application, performance and availability of component parts and materials. He can accumulate data from the actual performance of a product, and can supplement this with experimental data. The sum total of this information can be compiled into an experience file on particular items, preferably arranged by type device, and subdivided by manufacturer.

With the data in his experience files, the Standards Engineer can supply sufficient information to a designer to evaluate the applicability of any given item to a particular design. It will then become obvious whether the item will perform reliably, whether another item has to be selected, or whether a change must be made.

With each additional activity of this sort, the experience file assumes more volume as well as more value. After just a few years such a file is impossible to replace. Its particular value lies in the fact that it is based not on just one design, but on many. While a

TO OPERATE EFFECTIVELY and efficiently, most Engineering Departments must have service organizations at their disposal. As a design proceeds from its initial stages, these service groups cooperate, in the areas designated below to supply technical data not readily available to Engineering, minimize delays, cut production costs and preclude the need for a redesign.



Service Dept.	Function of Service
Standards Engineering	Conformance to specifications. Controls over possible overdesign. Controls over possible injudicious choice of component parts and materials. Controls over standardization of procedures and components.
Production Engineering	Problems concerned with the adaptability of the design to production processes.
Quality Control	Problems concerned with the adherence to established production procedures and with the performance of the product.

PARTIAL LIST of the activities of three service groups. Each group may exist in various forms ranging from one or two persons to a complete department depending upon the needs and resources of the company. However, it is generally poor economy to omit any one of them.

project engineer, or a designer, has spent a year or more on one large project, the Standards man has supplied information to several designs, and has followed up on their performance. The project personnel may, for example have utilized a particular thermostat in a given application. But the Standards Engineer may have seen the same thermostat used in several designs with different requirements. He can therefore accumulate experience information on the item in many different applications, and thus become expert on a detail. Then, when a new design arises, he has a broader viewpoint and wider experience in the use of the item. With information based on this kind of experience he can supply information to new projects which the appropriate project personnel could not possibly have at their disposal.

His contact with vendors of component parts enables the Standards Engineer not only to determine applicability and reliability, but also to advise on the availability of these items. A consideration of delivery time is often highly important when schedules have to be met, or replacement parts must be obtained. Thus, knowledge of availability may lead to a recommendation to purchase an excess quantity, or to purchase material well in advance of the need, or even to modify a design to utilize more available components.

In similar fashion, the Standards Engineer can supply information with little delay where cost is concerned. His experience in this field can be particularly helpful when considering new designs.

His files and experience enable him to give expert advice on materials and finishes as well as on components. This is well exemplified by the use of cadmium plating. Although cadmium plating has become a standard finish in many applications, it must be treated with caution. Cadmium is known to have flaked when applied to aluminum products that were used in the vicinity of chlorine bearing compounds such as polyvinyl chloride insulation. This could leave a surface unprotected, where the danger of corrosion exists or the flakes could damage a precision gear train. There is also the danger of the release of toxic fumes when high temperatures exist. Thus, although cadmium plating is in itself a desirable protective coating, there are certain circumstances when it should not be used. Frequently such a consideration may involve a violation of a specification, particularly with military products. In this case, a deviation would have to be obtained.

4. What New Components Will Be Available?

All of the activities of the Standards Engineer, as described thus far, have indicated that his is a consulting activity. He is an advisory expert to project and design personnel, a time saving expert. However, his knowledge is derived not only from experience, but also from his contacts outside his company structure. These include the vendors of component parts and materials as well as civilian and governmental specifying agencies, professional organizations, and local governments. His contacts here are not only in the nature of an information-gathering activity, but again also as a consultant. They can often lead to changes in component parts. He may induce a vendor to change a particular characteristic of one of his products. They may also lead to changes in specifications, when a specification is found to be too rigorous to permit reasonable conformance, or they may lead to increased requirements where a specification is too lenient. As a matter of fact, specifying organizations frequently send advance copies of new specifications to Standards Engineers of interested companies to obtain their comments prior to release. Such a poll is conducted among manufacturers of the item to be specified as well as the users. On the basis of such data it is possible for the issuing agency to make a specification more universal and complete.

5. What Components Are Stocked?

Many companies use a Standards Manual to list components that are kept in stock or, at least, are used frequently. Thus, such a manual in itself is not new, but it is a rarity to find one that is considered satisfactory. To be of real value, it should be comprised of two major sections: (1) a Standard Parts Manual, and (2) a Standard Process Manual. Both are written by the Standards Department, and a large part of the information therein is based on the work that the Department has conducted as described in earlier sections. It is rounded-out with information pertaining to the company's own products.

The first part of the manual, Standard Parts, contains detail specifications of purchased items. These are usually assigned a part or stock number which should also be listed in the manual. The detailed specification should include these factors: functional characteristics; performance characteristics (qualification); outline dimensions; mounting dimensions; finish; materials; approved vendors and their catalog number; and inspection procedures.

The existence of such a manual does not, of course, mean that a designer may not call for the use of another part, not currently listed. A manual will never be that complete, because new designs may of necessity require parts never before used. But the manual does save time as well as reduce the number of different parts. Typical of items that should be listed in the manual are terminals, wire, shockmounts, vacuum tubes, solenoids, electrical and mechanical hardware, and bearings, to name a few.

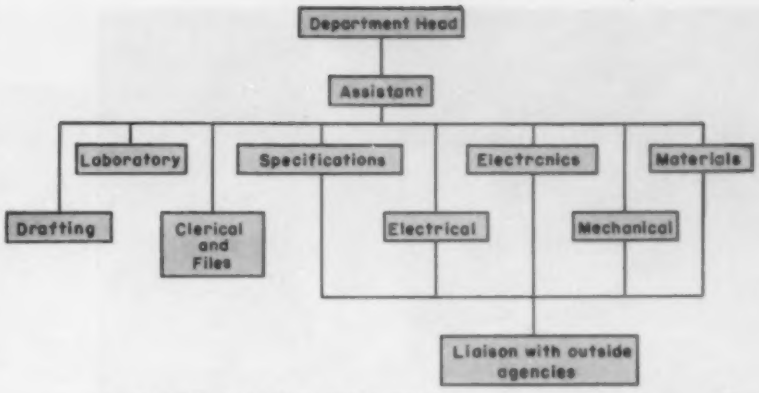
The manual will contain more data than most catalogues, being based on evaluation tests as well as on past performance. An example is shockmounts. There are a number of manufacturers of these devices, and their products generally differ in some form.

The variety is a fairly large one. Thus, when such an item is required, the designer may call for a unit from some manufacturer's catalogue. At the same time, on another design, a different catalogue may be consulted for the same, or similar device. In this case it would lead to excessive expense in specifying two similar devices from two different sources at the same time. This would require separate purchasing activity as well as inspection procedure.

A Standard Parts Manual would probably list shockmounts, already assigned stock numbers and under procurement, that may very well fulfill the requirements of both designs. They would be classed by load range, and data would be included giving the natural frequency, outline and mounting dimensions, materials used, finish, ruggedization, if any, stock or part number, and vendor. There would also be certain standard design concepts and formulas, as a guide not only in selecting the device, but also in applying it in the most efficient and suitable manner.

Of the many items listed, several will be marked for regular stock. These are items for which there is continuous need in fairly large quantity. And, stock would be maintained in this fashion not only for manufacturing purposes, but also for laboratory use.

How such a manual will aid the performance of a product as well as economy of design is well exemplified in the case of vacuum tubes. There is a large variety available under different labels, such as "standard tubes", "special", "ruggedized", "reliable", "JAN", and "preferred" tubes. Typical thereof is the 6AQ5, a miniature type pentode, frequently found in automobile radios, where it does an admirable job. Yet, particular usage found the tube to be unreliable in certain applications, and a ruggedized version, the 6AQ5W, was introduced. This tube could withstand more shock and vibration, but was found to have undesirable electrical performance characteristics in certain applications. In particular, it was found that in the case of accentuated miniaturization there was a tendency to "overdesign". The tube was rated very close to its performance limits, with respect to plate dissipation. Thus, it became necessary to introduce a "reliable" version, the 6005, which is not only rated somewhat more conservatively, and designed somewhat differently, but is also produced under more stringent quality control than the prototypes. It is concededly more reliable, and of correspondingly higher cost. However, although it is a so-called premium tube, it is still possible to overdesign a circuit using the tube, and thereby to reduce its reliability. A standard manual not only might list these tubes, together with their performance characteristics, but might also include recommended design limitations for the purpose of assured performance in the final product. In the extreme possibility, an overdesign may be carried so far that the performance of even a premium tube is in doubt, and selected tubes only can be used. This is so, because even premium devices have tolerances, and although thinking in tolerances is routine where dimensions are concerned, it is not necessarily routine where electrical performance characteristics are concerned.



SCHEMATIC ORGANIZATION CHART for a Standards Department. The actual number of personnel required would be determined by the size of the company and the number and diversity of its products.

A project engineer will find additional help in the use of a Standard Parts Manual when he desires to locate a part such as a time-delay device. Depending upon the frequency of the signal voltage as well as the length of delay required, there are time-delay networks, time-delay relays, thermal devices, and motor-driven devices to name a few. Several of these may overlap in their delay characteristic. The best type to use depends not only upon the aforementioned characteristics, but also upon the design application. The question an engineer will ask is: Which type of device is applicable? He has to consider among others the desired length of delay, available power to operate the device, and the necessary re-cycling characteristic. What has to be determined is the length of time permissible for the device to restore itself to repeat the delay cycle. Furthermore, the environmental conditions that the device may be subjected to have to be considered. All of these factors could be listed in the Standard Parts Manual.

In similar fashion it is advisable to specify particular processes during the manufacturing stage of a product. For this purpose the Standard Process Manual is prepared. It contains information on how to wire components, such as resistors, into assemblies, on the choice of drill and reamer sizes for particular types of pins, on methods of welding and soldering, the choice of soldering flux, and on the application of paints and varnishes, to name a few.

This manual would specify particular items, such as taper or roll pins, or dowel pins, and would list the appropriate drills and reamers to be used, as well as the stock numbers of the items.

Wiring components into an assembly may also be intricate enough to warrant a special process instruction. Excessive tension, or sharp bending, may break a lead from a resistor. A minimum length of loop of the wire must be specified to avoid possible damage. Although the cost of the component may be negligible, the labor involved in first installing, then removing, and then re-installing the component is considerable.

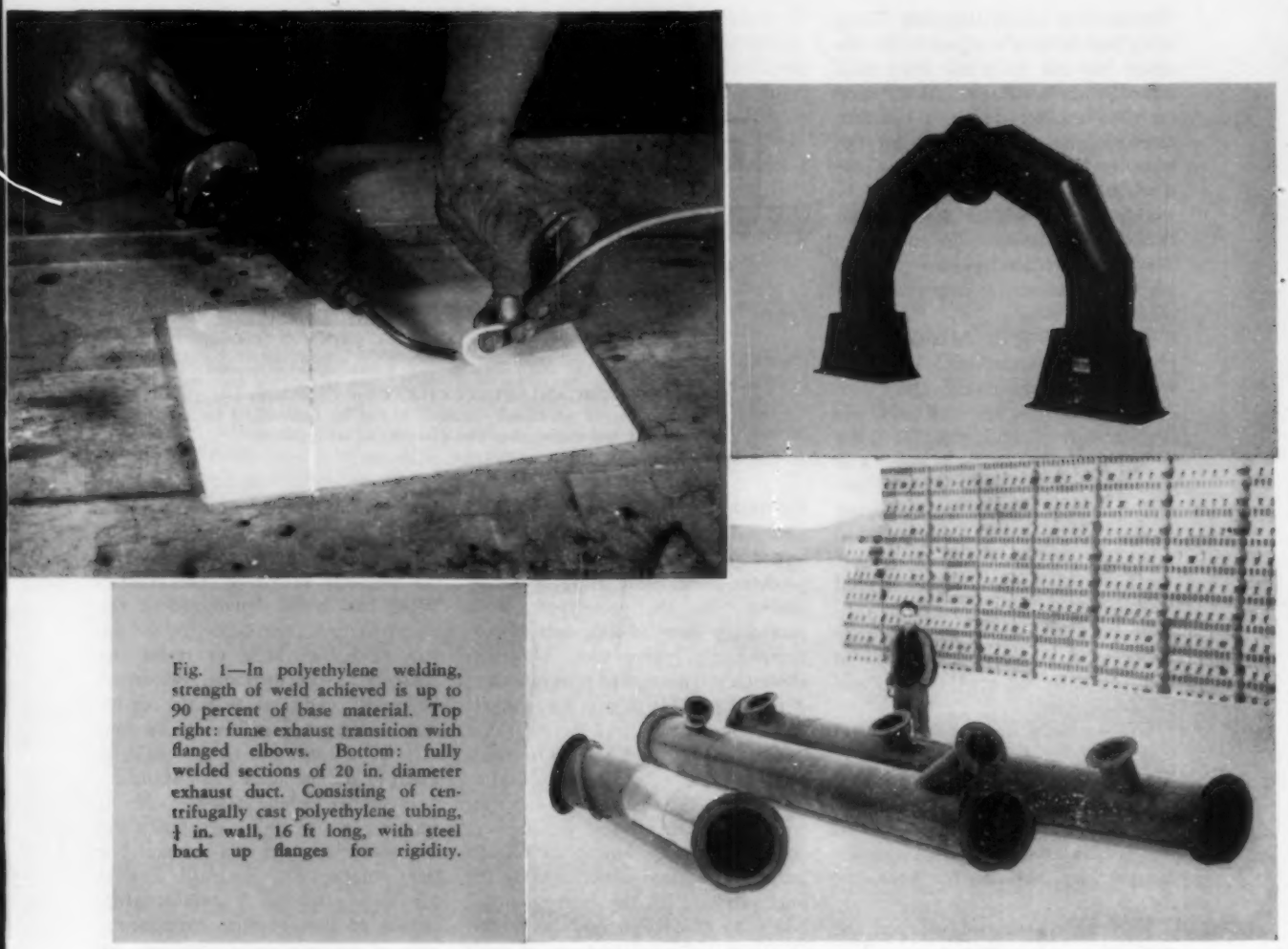


Fig. 1—In polyethylene welding, strength of weld achieved is up to 90 percent of base material. Top right: fume exhaust transition with flanged elbows. Bottom: fully welded sections of 20 in. diameter exhaust duct. Consisting of centrifugally cast polyethylene tubing, ¼ in. wall, 16 ft long, with steel back up flanges for rigidity.

Polyethylene's Potential in . . . Large

A. J. NEUMAN
President, American Agile Corporation

Developed as a dielectric, polyethylene is now bidding for structural applications in welded units, primarily where lightness in weight and corrosion resistance are decisive factors.

THE APPLICATION OF POLYETHYLENE, since its introduction, has been, and still is, predicted to be extremely large, but this prediction has been applied to volume use rather than size of application. Demand has far exceeded supply with the majority of its uses being in wire and cable insulation and film. But its production is on the increase; based on the institution of new production units, its availability is expected to increase more than 50 percent during 1954, so that its potential as an engineering material (*Product Engineering*, July 1952) can be realized more fully in industrial applications, including large plastic structures, fabricated by hot gas welding—joining sheets, plates, molded sections, and extruded and centrifugally cast tubing into structures of virtually unlimited size.

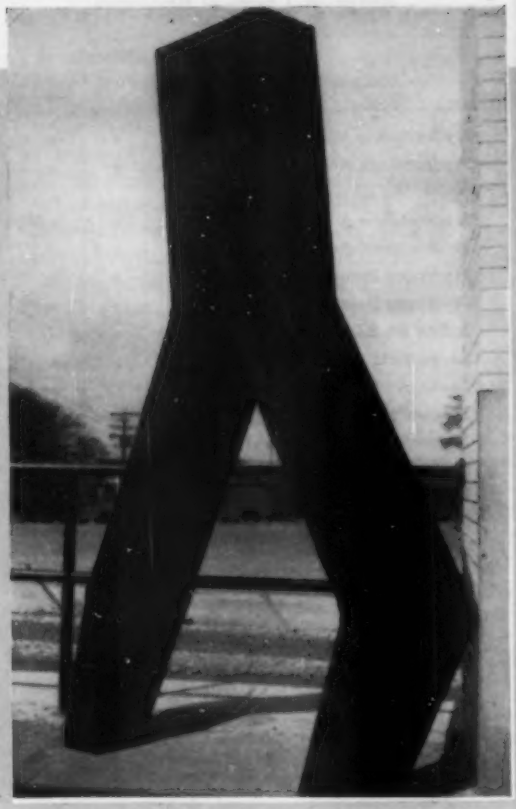
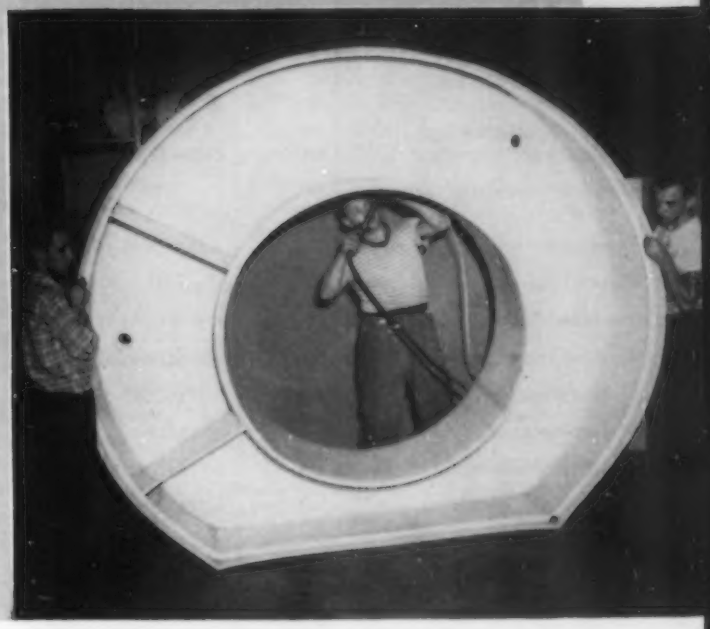


Fig. 2—Ten ft rectangular design ductline. Welding was performed with triangular spline in one corner after bending sheets. Fourteen in. by 12 in. fork ends in 22 in. by 12 in. rectangular fan outlet.

Fig. 3—Fully welded polyethylene TV picture tube washing machine, 105 in. OD. Material thickness is ¼ in. and ⅛ in. Sink is used during rinsing of glass tubes with hydrofluoric acid and strong alkaline cleaning solution, in the different sections.



Plastic Structures

A tough, semi-flexible, impact-resistant plastic, polyethylene's potential for such structural use as components of ventilating and air or liquid conveying systems, as well as preliminary design models, is widespread because:

1. It has a high softening point and good mechanical properties, Table I, over a wide range of temperatures. In low temperature impact brittleness tests, it has resisted failure at —76 F., and installations have been in service at temperatures as high as 150 F. and frequently 175 F. Since it is semi-crystalline, semi-amorphous in structure, many of its mechanical properties are analogous to those of micro-crystalline, non-ferrous metals such as lead, copper, or brass. Its stiffness is midway between rigid and flexible materials—in thin sections, from .004 inch to .125 inch, it is quite flexible; above these, it is stiff and hard. Although polyethylene may be stretched up to 600 percent before rupture occurs, these elongation factors are not recoverable. With a stress-cracking behavior similar to that of brass and other metals, polyethylene materials subjected to intermittent or constant strain in excess of ten percent will fail if they are in contact with organic liquids ordinarily assumed harmless. For strain levels not exceeding about ten percent, contact with these organic liquids does not affect polyethylene's properties.

2. It exhibits outstanding resistance, with the above restrictions, to a broad range of chemicals, Table II. Polyethylene resists the corrosive attack of acid, alkalies, and other chemicals. In an inert atmosphere, no decomposition

Table I—Average Physical Properties of Weldable Polyethylene*

	Value	Test Method
Specific Gravity	0.92	
Tensile Strength, psi.	2,000	ASTMD638-49T
Elongation, %	100–400	ASTMD638-49T
Modulus of Elasticity, 10^5 psi	.19	ASTMD638-49T
Impact Strength, Izod, ft. lb./in. of notch	16	ASTMD256-47T
Thermal conductivity, 10–4, cal/sec/cm²/°c/cm	8.0	Cenco-Fitch App.
Dielectric Strength, short-time, v/mil	460	ASTMD149-44T
Compressive Strength, psi	280	ASTMD695-44T
Flexural Strength, psi	1500–1700	
Hardness, Rockwell	11–35	ASTMD785-48T
Coeff. of linear expansion, 10^{-5}/°c.	16–18	ASTMD696-42T
Volume resistivity, ohm-cm	3×10^{17}	ASTMD257-46T
Water absorption, % in 24 hrs.	<0.01	ASTMD570
Dielectric Constant, c.p.s.	2.3	ASTMD150-47T
Power Factor, c.p.s.	<0.0005	ASTMD150-47T
Brittleness Temperature, °F	< −76	ASTMD746

* Values vary slightly with different grades.

of polyethylene is encountered even at temperatures as high as 650 F. Polyethylene is insoluble in water and organic solvents at normal room temperatures. At temperatures of 122 to 140 F some organic liquids show a solvent effect on the plastic causing it to swell and dissolve. This characteristic, excellent chemical resistance, superior to that of polyvinyl chloride, another structural plastic, makes it extremely important to applications where corrosion is a decisive factor in material selection.

As it requires no painting for protection against moisture or chemicals, neither does it require painting for decoration. For construction purposes, polyethylene is usually available in either natural or black colors.

3. It possesses electrical insulating properties superior to most plastics, with the possible exception of fluorinated ethylenes. Developed primarily as a dielectric material, polyethylene, a non-polar molecular structure, has a very high resistivity, a high dielectric strength, a very low power factor, and a low dielectric constant.

4. It can be fabricated readily by injection molding, blow-molding, extrusion, and a process important to its

Table II—Polyethylene's Range of Chemical Resistance

Reagent	Concentration	Reaction at 70 F	Reaction at 140 F
Hydrochloric Acid	10%	s	s
Hydrochloric Acid	more than 35%	s	s
Hydrochloric Acid	40%	s	s
Hydrochloric Acid	75%	s	o
Hydrogen Peroxide	30%	s	o
Hydrogen Peroxide	90%	s	u
Iodine (in KI Sol'n)	conc.	o	u
Lactic Acid	10%	s	s
Lactic Acid	90%	s	s
Magnesium Chloride	.....	s	s
Magnesium Sulphate	.....	s	s
Methyl Bromide	.....	o	..
Nickel Sulphate	.....	s	s
Nitric Acid	10%	s	s
Nitric Acid	30%	s	s
Nitric Acid	70%	s	o
Nitric Acid	95%	o	u
Ozone	.....	o	u
Petroleum Ether	.....	u	u
Phosphoric Acid	30%	s	s
Phosphoric Acid	90%	s	u
Potassium Borate	.....	s	s
Potassium Carbonate	.....	s	s
Potassium Chloride	sat. sol'n	s	s
Potassium Dichromate	40%	s	s
Potassium Hydroxide	all conc.	s	s
Potassium Nitrate	.....	s	s
Potassium Permanganate	.....	s	s
Silicic Acid	.....	s	s
Silver Nitrate	.....	s	s
Sodium Benzoate	.....	s	s
Sodium Bisulphite	.....	s	s
Sodium Carbonate	dil. sol'n	s	s
Sodium Carbonate	conc.	s	s
Sodium Chlorate	sat. sol'n	s	s
Sodium Chlorate	sat. sol'n	s	s
Sodium Hydroxide	all conc.	s	s
Sodium Sulphate	.....	s	s
Sodium Sulphide	.....	s	s
Stannous Chloride	sat'd	s	s
Stearic Acid	100%	s	s
Sulphuric Acid	10%	s	s
Sulphuric Acid	70%	s	o
Sulphuric Acid	98%	o	u
Tannic Acid	10%	s	s
Toluene	.....	u	u
Trichloroethylene	.....	u	u
Zinc Chloride	sat'd	s	s
Zinc Sulphate	sat'd	s	s

S = Complete Resistance
O = Some degree of attach
U = Attack or Decomposition

structural use, centrifugal casting, in which dry powdered polyethylene is held against the walls of a rotating, heated metal cylinder by centrifugal force.

Standard cast polyethylene tubing, Table III, ranges in outside diameter from 2¾ inches to 20½ inches. Sheets of polyethylene can be obtained from ¼ inch to 1 inch in thickness, and, in width, 48 inches by 72 inches, ±5 percent. Polyethylene blocks, available for machining into suitable shape for structural welding, are usually 12 inches by 12 inches in height and width, with thickness varying from 2-4 inches.

Through the process of welding, it becomes possible to extend the size of all-plastic assemblies to an almost infinite degree. Welding also offers a means of producing shapes not otherwise obtainable, as well as a method of repairing and rebuilding damaged thermoplastic components. The basis of plastic welding is in the nature of thermoplastics. They soften and can be brought to coalescence when heated, and upon cooling, regain their rigidity. During the last few years, hot gas welding of polyethylene has been applied with particular success to a large and ever increasing variety of constructions. The strength of welded seams produced in polyethylene by this method is as high as 90 percent. Polyethylene welds resemble the types produced by electric arc welding. For the fillet weld no preparation is needed.

Table III—Standard Cast Polyethylene Tubing

O.D., in.	I.D., in.	Weight per ft.
2.75	2.375	0.605 lb.
3.0	2.625	0.690 lb.
3.625	3.250	0.810 lb.
4.0	3.625	0.910 lb.
4.75	4.375	1.080 lb.
5.625	5.250	1.280 lb.
5.75	5.250	1.730 lb.
6.625	6.125	2.000 lb.
8.50	8.000	2.650 lb.
10.25	9.750	3.200 lb.
12.50	12.000	3.850 lb.
14.50	14.000	4.500 lb.
17.50	17.000	5.750 lb.
20.50	20.000	6.500 lb.

For the butt weld, the two pieces are bevelled in the manner used in arc welding, but at a smaller angle, approximately 60 to 80 deg, and with no sharp edges. Such bevelling may be performed by sawing, filing, or grinding. A filler rod of the correct diameter which will more than fill the chamfer on the two parts being welded is used. One end of the filler rod is inserted in the chamfer and warmed up until it softens. The softened end is bent into a right angle, Fig. 4, and inserted where the weld is to start. The torch is then moved vertically and the hot gas stream is directed simultaneously against the filler rod and edges of the chamfer. This permits the deposition of multi-layer welds for heavier structures. Contrary to the welding of metals, the penetration of the filler rod into the base material is very limited, despite the achievement of 90 percent of strength in the weld. Slight uniform weaving motion of the torch nozzle achieves uniform heating of the parent material and rod. The chamfered part will require slightly more heating for the weld than the filler rod in general practice.

Slight pressure is also exerted in the vertical direction on the filler rod in order to achieve proper bonding. The filler rod should be held almost perpendicular and the jet should be maintained at an angle of about 30 deg to the plane of work and directly in line with the weld. The jet is then moved as the weld progresses so that the vertical portion of the rod is always kept as equi-distant from the torch as possible.

Since polyethylene welding is relatively new, knowledge of joint and weld design is scant. A review of the progress made since 1937, when the welding of plastics was first attempted, shows that the welding of plastics is on its way toward becoming a standard method of fabrication. Among the thermoplastics which have been found weldable, the first which acquired importance was the polyvinyl chloride group of plastics in Germany, while, in England and America, development has centered on polyethylene, which was not introduced commercially on any large scale until the mid 1940's. However, the knowledge of welding polyethylene is growing so that large polyethylene structures are presently being used in rayon and textile equipment, electroplating and glass etching vats, light bulbs and television tube manufacturing, paper mill systems, food processing equipment and bleaching and dying apparatus.

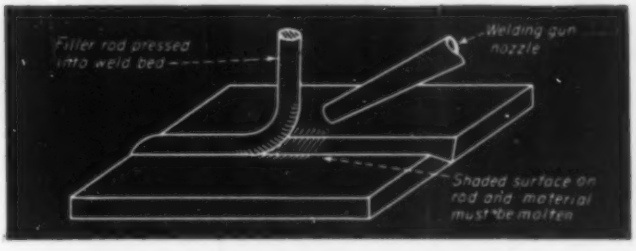


Fig. 4—Polyethylene welds resemble types produced by electric arc welding, but contrary to welding of metals, penetration of filler into base is limited.

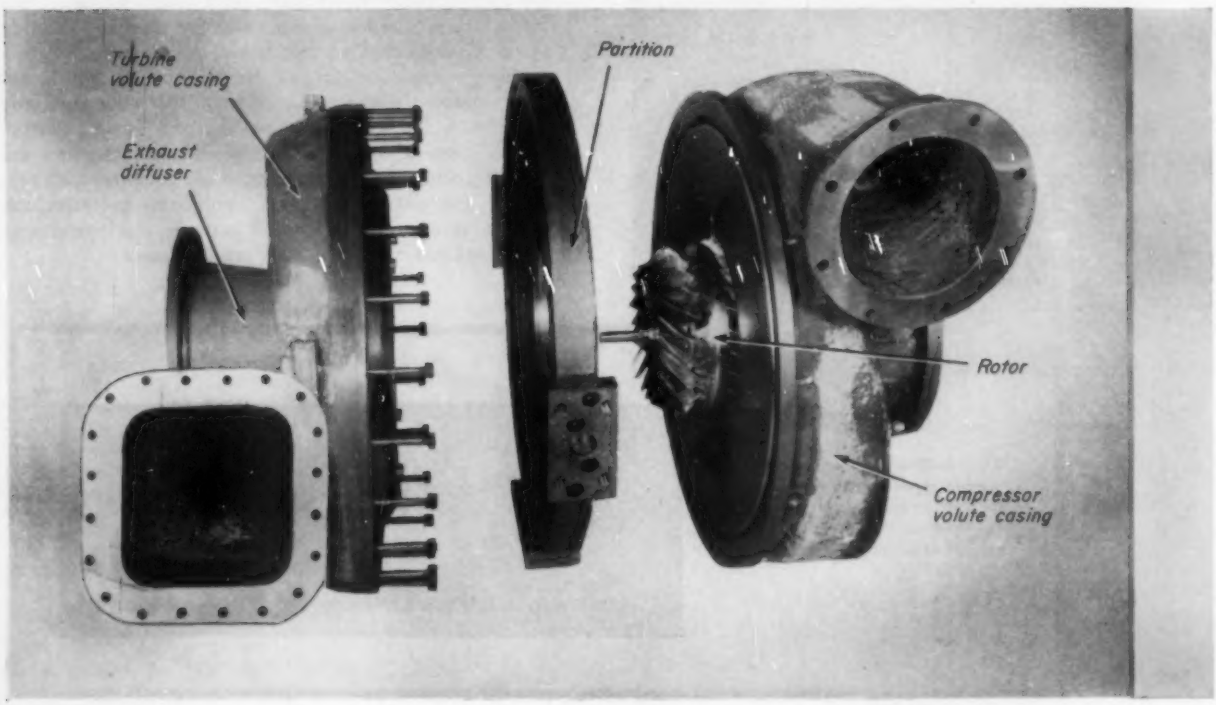
DESIGN FEATURES

High-Pressure Turbocharger Uses

Built for pressure ratios as high as 3:1, the new turbocharger developed by the De Laval Steam Turbine Co., Trenton, N. J., has its compressor impeller and turbine wheel arranged back-to-back, to form a single rotor structure. This "Monorotor" design substantially reduces windage, leakage and friction losses, an important factor in the high combined efficiencies obtained—up to 68 per cent. Translated into Diesel engine performance, this high pressure turbocharging pushes specific engine outputs to 190 psi bmep and higher, about 2½ times more than those possible from unsupercharged engines.

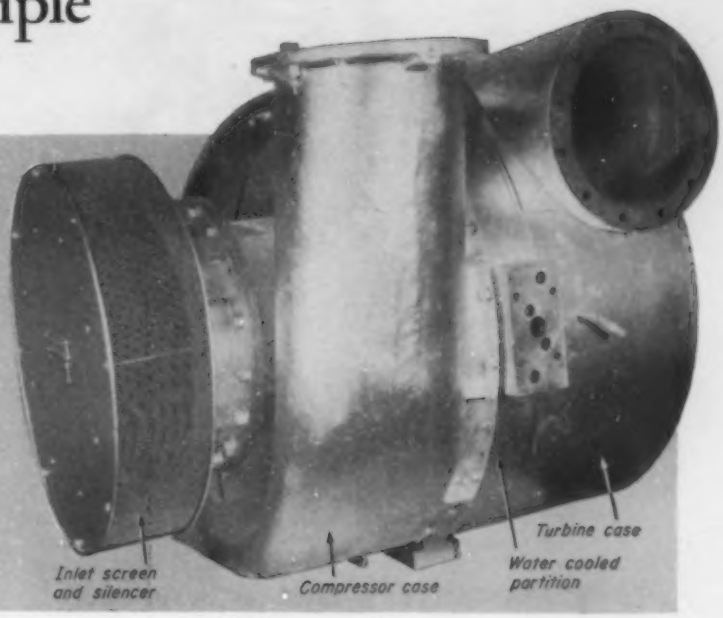
Principal difference between new turbocharger and others recently developed (Product Engineering, October 1953, pp. 158-159) is the construction of the rotor. Blades of the mixed-flow compressor and the centripetal turbine are arranged on opposite sides of the rotor hub, the rotor being overhung and secured to the end of the shaft with a tie bolt.

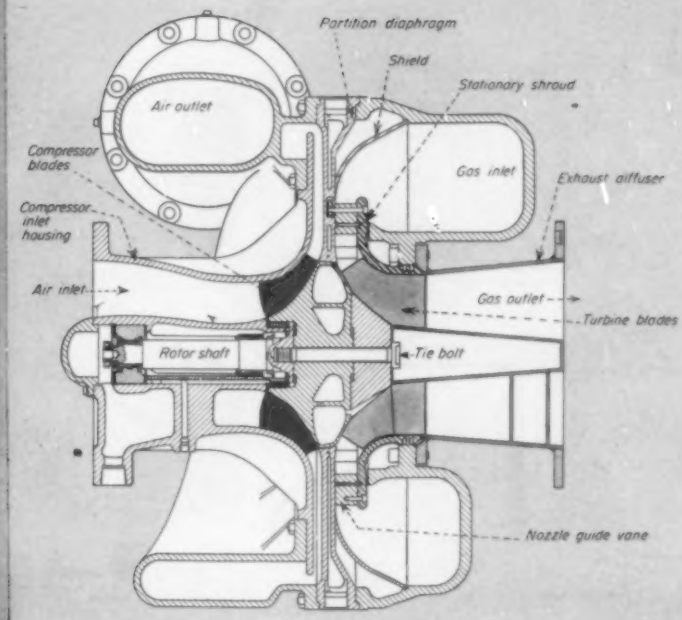
"Monorotor" principle simplifies the design by reducing the number of air and gas seals and partition walls normally required. Also, it allows simple cooling of the turbine by the direct transfer of cooling air from the compressor to the turbine side. Air is bled to turbine blades and roots.



Monorotor Principle

Turbocharger unit shown is designed for a manifold pressure of 2:1 under full load engine operating conditions. Compressor and turbine housings can be rotated relative to each other, to simplify attachment to different engine intake and exhaust manifold arrangements. Rotor operates at 17,000 rpm., and delivers air up to 10,000 cfm for combustion and scavenging. Weight of illustrated turbocharger is but 130 lbs.





(LEFT) Exploded view of turbocharger shows the overhung mounting of the rotor. Partition separating the nozzle box and compressor housing is the unit's only water-cooled element. Turbine housing is fabricated from a heat-resistant alloy and is insulated and lagged.

(RIGHT) Cross section of turbocharger. Exhaust gases enter the turbine volute housing in a tangential direction, the nozzle guide vanes directing the flow radially inward into the turbine blading. After passing through the blading, gases are discharged axially into an exhaust diffuser. At other end, air is admitted axially into the compressor blading. Mixed-flow impeller and curved stationary passage discharge the air radially into a vaneless diffuser to the volute housing.

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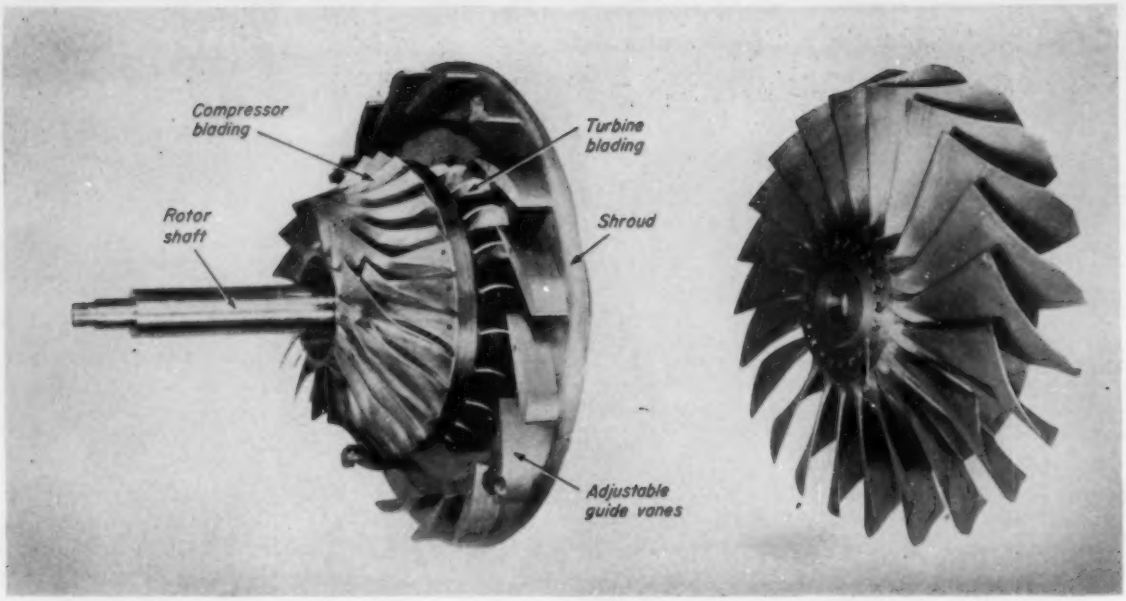
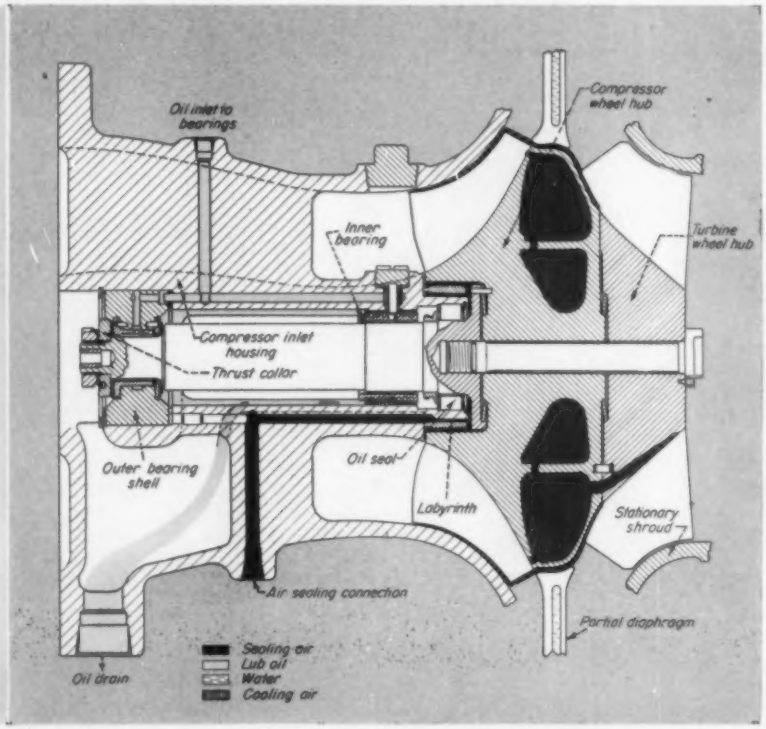


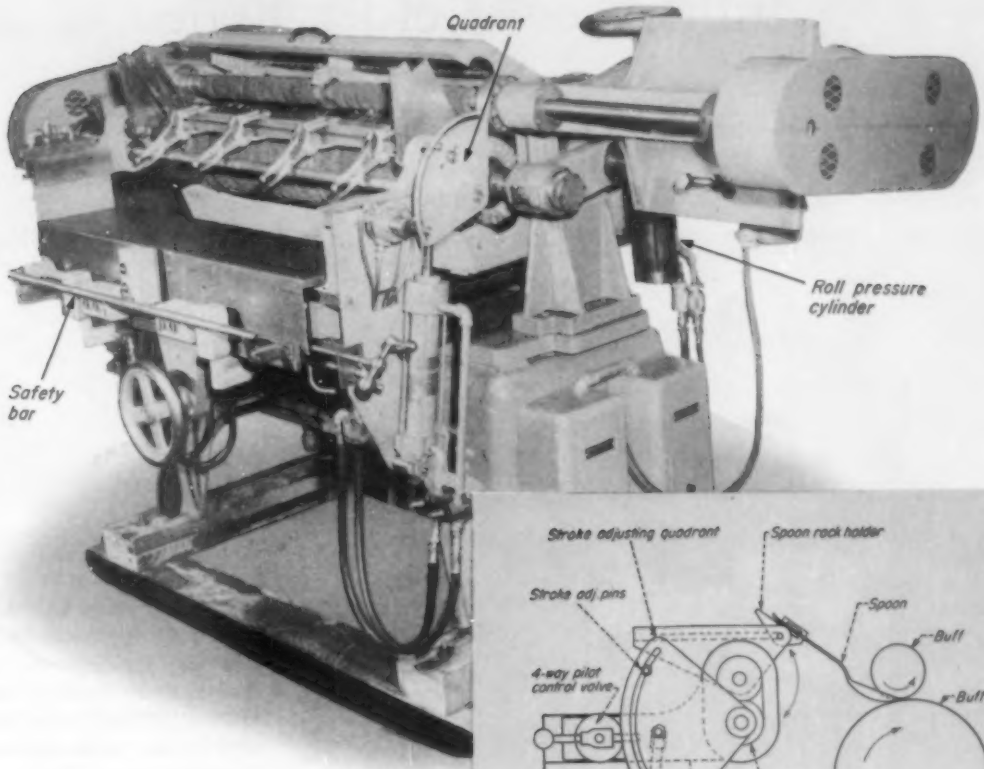
(LEFT) Adjustable guide vanes, mounted on the turbine shroud, permit exact matching of turbocharger to engine. Vanes are pivotted to change the nozzle area and the tangential flow of exhaust gases into the blading. Holes around the circumference of the impeller hub permit the flow of cooling air into the hollow interior of the hub and also through passages adjacent to the turbine blade roots. Because of turbine action in cooling air flow, turbine efficiency is not reduced.

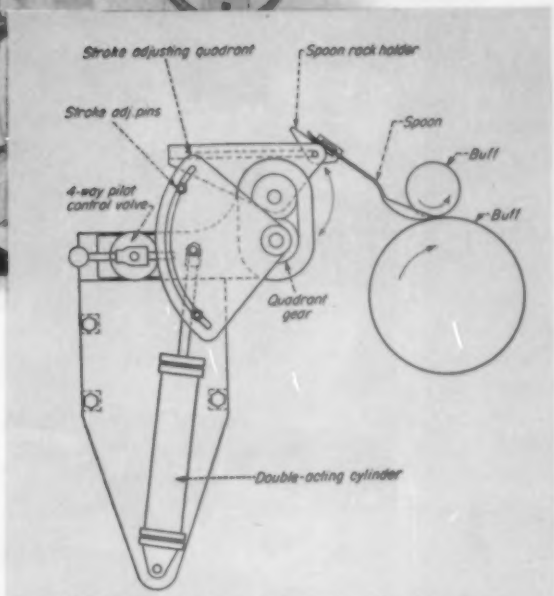
(RIGHT) Turbine blades are made with double-dovetail roots and are inserted into corresponding grooves cut in the outer conical surface of the wheel hub. Copper brazing is used to lock the blades in place. Recent developments now enable the entire hub and blading to be made as an integral piece.

ROTOR COOLING and lubrication. Air is bled through the clearance between the rotor O.D. and the I.D. of the partition diaphragm, for cooling the turbine wheel. Also, air is circulated through the hollow rotor, entering through holes in the impeller periphery and leaving through cooling passages next to the turbine blade roots. Rotor bearing are lubricated with engine oil, and are contained in a common housing that is an integral part of the compressor inlet housing. Lubricating oil is prevented from entering the compressor inlet housing by a seal which is pressurized with air bled from the compressor volute casing.



Hydraulically-Operated Quadrant Furnishes Adjustable Rocking Motion





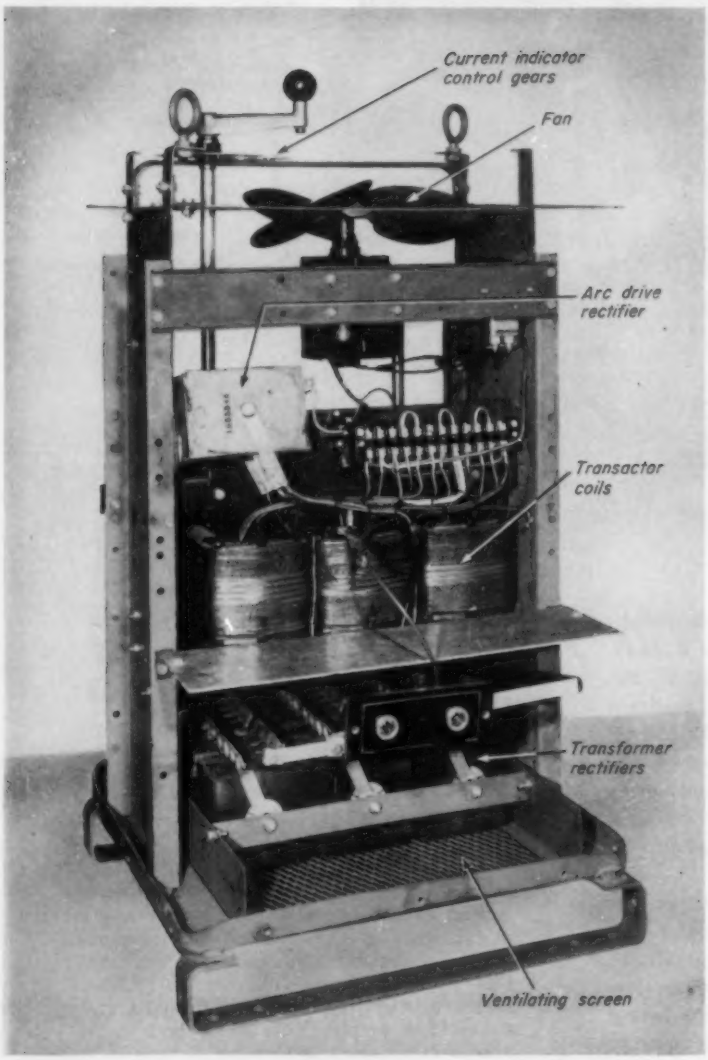
OSCILLATION of the work racks is accomplished by the rocking of the work fixture gear about the quadrant gear. In operation, reciprocation of the double-acting hydraulic cylinder piston rod occurs each time the stroke pins trip a 4-way pilot control valve. Adjustments for work piece bowl depth and length are made by simply repositioning the two trip pins in the quadrant slot.

In the design of a machine to mechanize the polishing of articles having concave and convex surfaces, the Clair Manufacturing Co., Olean, N. Y. has adopted a simple hydraulically-operated quadrant mechanism to "rock" the work between the buffing rolls.

Use of this hydraulic arrangement not only gives the operator a quick and positive means for adjusting the work stroke, but also minimizes the possibility of abrasives entering the system.

Included in the machine design is an independent air circuit connected to a pneumatic cylinder which maintains an automatic float of the buffing rolls at any predetermined uniform pressure. Pressure acts on the bottom of a piston to force apart the rocker arms attached to the roll shafts. Rolls are quickly opened by a safety bar operating a relief valve.

Standardization for Production Influences Welder Redesign



VIEW OF WELDER with covers removed shows palletized arrangement of components to simplify assembly and improve cooling. Air is drawn through bottom grill, flows through rectifier stacks up through coil windings and out louvres in top. Note drilled holes in frame; many will be used in assembly of forthcoming a-c welder line. Design target is maximum production flexibility.

Welding equipment manufacturers, faced with a paradoxical situation that has seen no significant change in the welding dollar since pre-World War II days, have offset costs of new improvements by production techniques that cost less. One example is Westinghouse Electric Corporation's recent redesign of its d-c selenium rectifier welder first introduced in 1949 (see *Product Engineering*, October, 1949, pp. 108-109). While keeping the same general welding characteristics, overload protection has now been added, the new welder line shows a concerted effort to reduce production costs by standardization and reduction in the number of internal connections.

First step was the standardization for maximum interchangeability of parts. Not only are many components now common to all d-c welder ratings, but will be with the a-c line under development. Besides permitting longer production runs

BASIC COMPONENTS are standardized in all Type RA welders. Single units, whether 200, 300 or 400 ampere rating, are same size: approximately 45 in. high, 23 in. wide and deep. Duplex models designed for 300/600 and 400/800 amperes are essentially two single units mounted on a common bed plate and enclosed in a single case. New a-c welders under development will be housed in same cases, and contain many parts now being used in d-c line.

from the same tools, this feature closes the gap between production and sales. Such items as bases, skids, side panels, covers, component supporting angles, moving reactor guide mechanism and mounting brackets can be pre-assembled regardless of welder type or rating. Then by practically bin-storing voltage and current control equipment on pre-assembled chassis, highly flexible production is obtained.

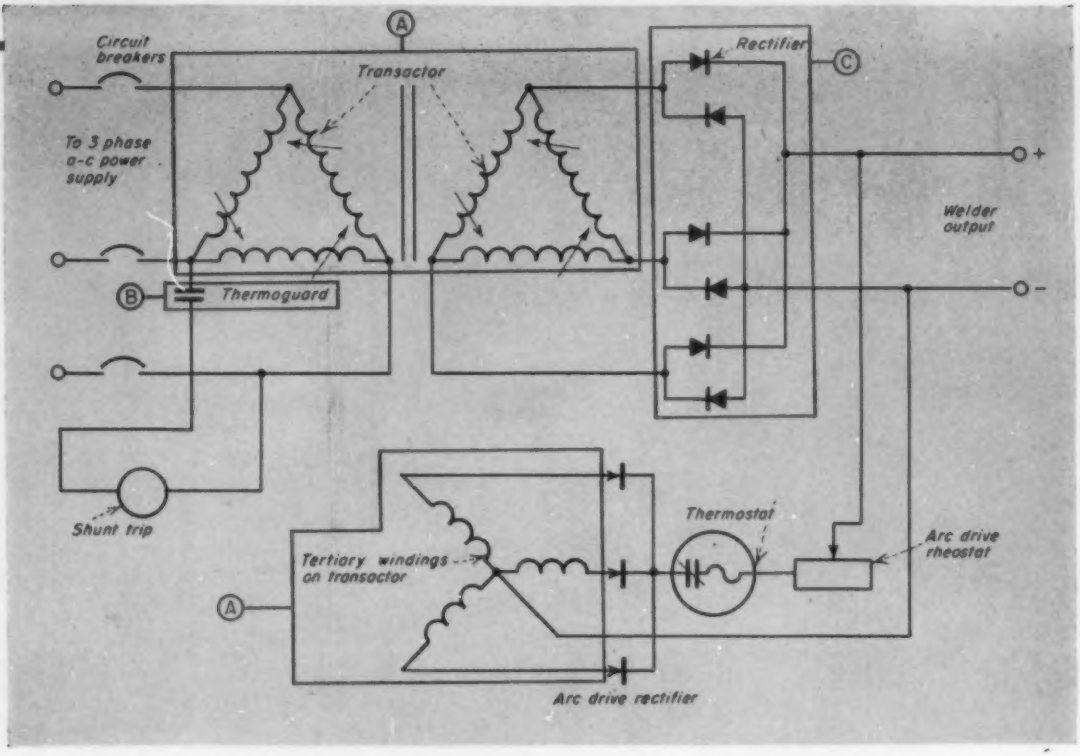
Wiring. New line represents first application of aluminum windings to replace conventional copper conductors in welder construction. While resulting in slightly larger coils because of aluminum's lower conductivity, principal advantages are less weight, use of a non-critical material, and a substantial savings in material cost. Copper terminals are still used (a softer alloy of aluminum is necessary for high electrical conductivity, hence clamping pressures would be critical). To join aluminum conductors to copper terminals, a special compound of petrolatum and metal powder is inserted in the terminal before being mechanically crimped. This gives a low resistance connection and prevents electrolytic action.

Another wiring change is the winding of the transformer and reactor coils. Previously wound separately and joined, the reactor for current control is now in series with the transformer secondary as a continuous winding. Internal connectors are eliminated.

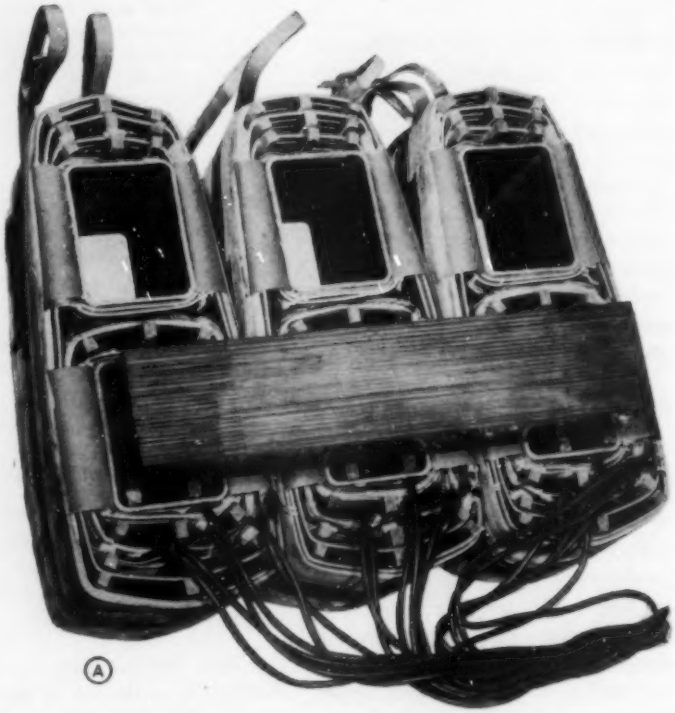
Cooling. Fan has been relocated, it is mounted on the top of the welder instead of at the side, to take advantage of natural convection air flow and a straight-line forced-circulation path through the welder. Other changes made: relocation of the rectifier unit from the side to the bottom of the welder, elimination of intake air hole in the side panel and slight increase in rectifier plate area for added cooling surface.

Overload. A simple bimetallic strip is imbedded in the transformer windings to energize a shunt trip mechanism. This opens a circuit breaker to shut-off the welder when coil temperatures reach the danger point. Welder cannot be operated until coil temperature has dropped allowing the bimetallic element to return to its normally-open position. Temporary overloads do not cause the strip to energize the shunt trip.

Welder Redesign (continued)



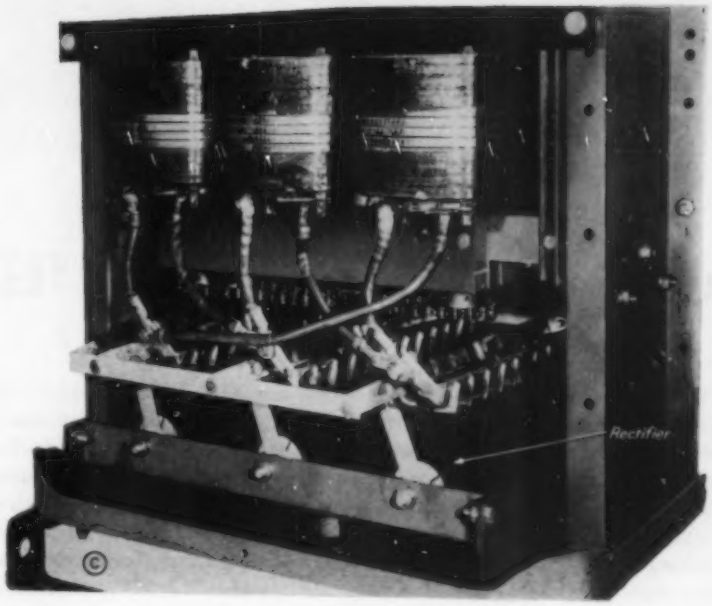
SIMPLIFIED wiring diagram of welder. Principal design changes are centered in (A) Transactor or combined transformer and series reactor, (B) Thermoguard or thermostat for overload protection and (C) Rectifier unit. Arc drive rectifier supplys current when load voltage drops below 21 volts, responding to transient characteristics of welding arc.

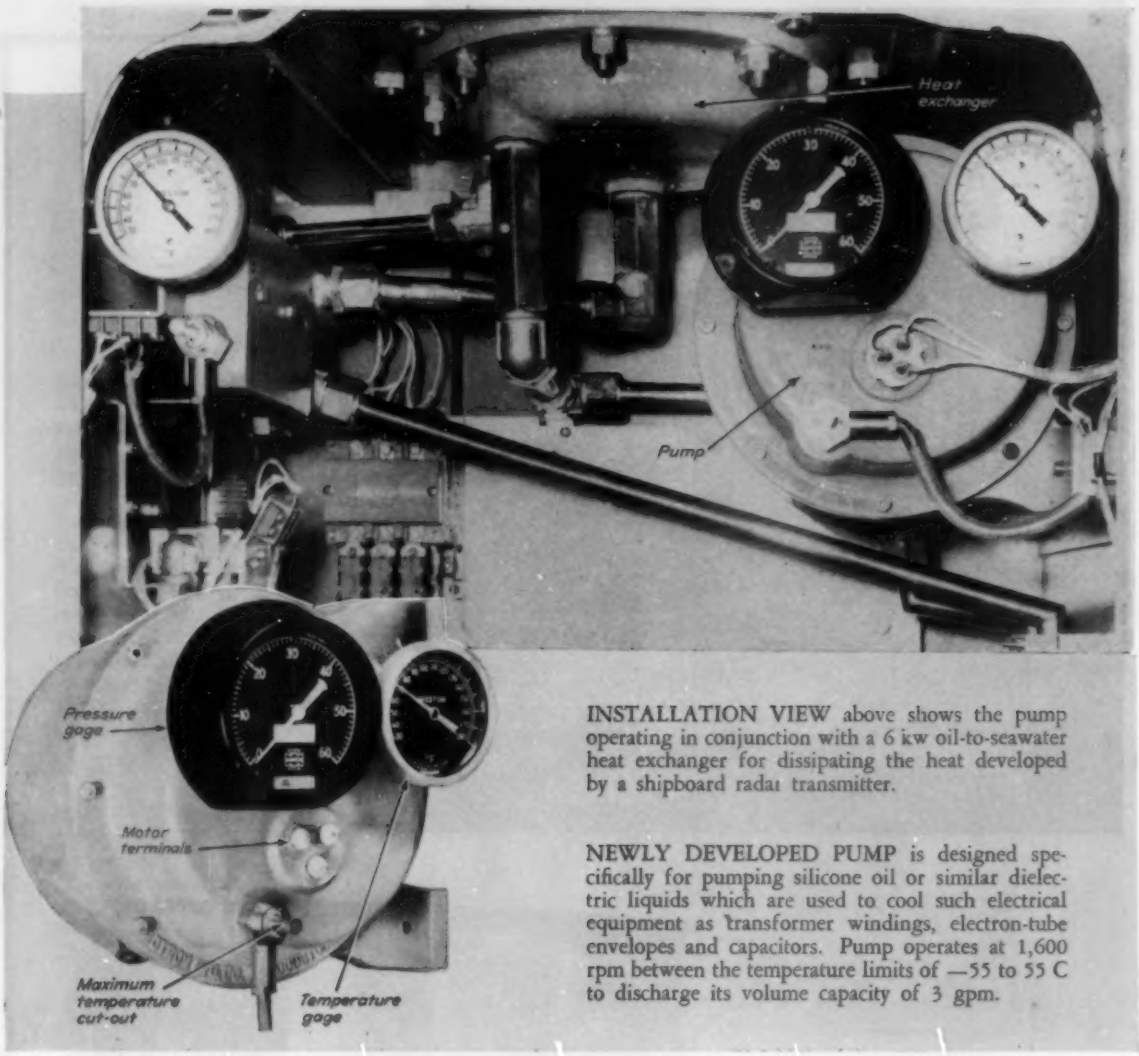


TRANSACTOR UNIT COILS are wound from Class B insulated glass-covered aluminum conductors. Transformer secondary and control reactor winding of each phase are wound as a continuous winding. Primary windings are wound on a micarta tube through which transformer core is inserted. Spacers between windings improve ventilation and give better cooling. Shown is the stationary core; moving reactor core fits in other tubes.

OVERLOAD PROTECTION is obtained by connecting a thermostat in series with a shunt trip coil which, in turn, is connected across a 220 volt winding of the primary transformer. A three-pole deion-type circuit breaker capable of repeatedly interrupting the maximum short-circuit current of the welder is also connected to the shunt trip mechanism. If the transformer coil overheats, thermostat closes energizing the shunt trip coil, thereby tripping the breaker and shutting the power off the welder.

SELENIUM CELL RECTIFIER is assembled as an integral unit, the size and number of rectangular plates depending upon the rating of the welder. Unitized construction permits ease of assembly into the welder frame and facilitates maintenance. Also shown are the primary and secondary terminals which are copper; they are mechanically crimped to the aluminum conductors, using a special paste.





INSTALLATION VIEW above shows the pump operating in conjunction with a 6 kw oil-to-seawater heat exchanger for dissipating the heat developed by a shipboard radar transmitter.

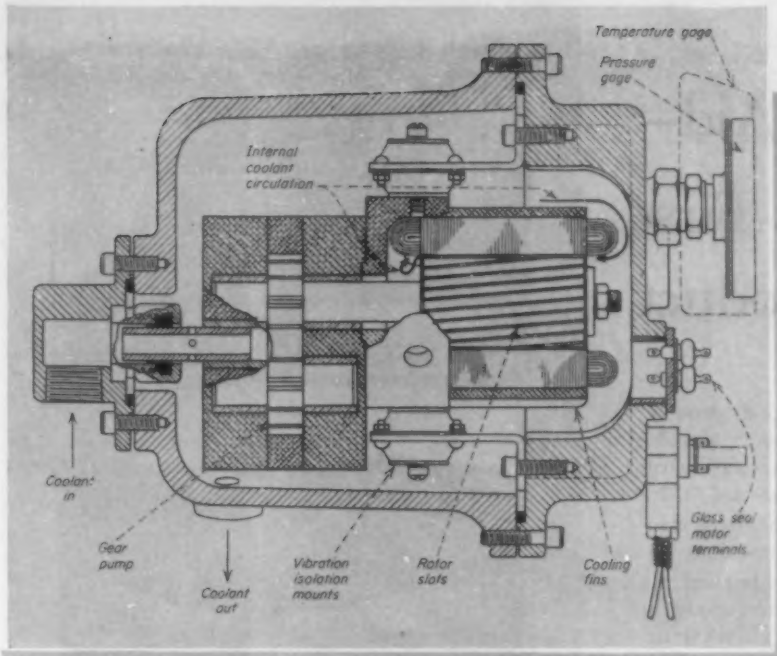
NEWLY DEVELOPED PUMP is designed specifically for pumping silicone oil or similar dielectric liquids which are used to cool such electrical equipment as transformer windings, electron-tube envelopes and capacitors. Pump operates at 1,600 rpm between the temperature limits of —55 to 55 C to discharge its volume capacity of 3 gpm.

Pump Uses Locked-Rotor "Heat" to Reduce

While primarily aiming the design of their new heat exchanger pump at savings in motor weight and size, the Rotron Manufacturing Co., Woodstock, N. Y., has come up with an unusual self-starting arrangement that is of significant value in very low temperature applications.

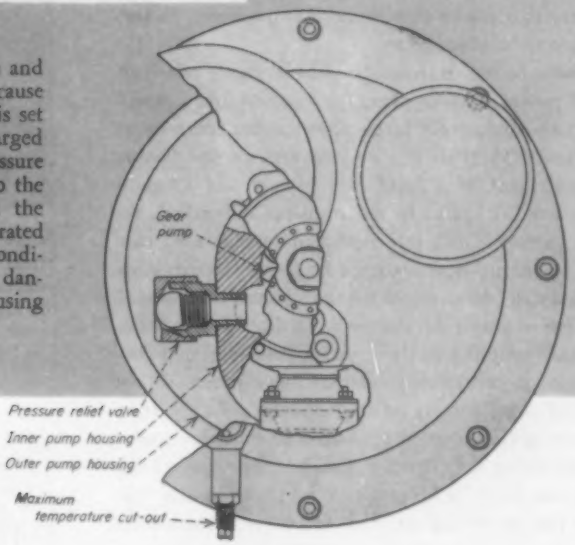
In the new design which consists of totally immersing the driving motor as well as the pump in the silicone oil cooling medium, the heat dissipated by the motor is directly transferred to the same coolant which the pump circulates. Thus, when the ambient temperature drops as low as —55 C, the high coolant viscosity prevents rotation of the pump. Power applied to the motor, the motor being in its locked rotor condition, is transferred into heat quickly dissipated by the windings to the surrounding cold oil. This rapid heat transfer, in time, reduces the viscosity of the oil and permits pump rotation and eventual normal coolant flow in the system.

Because of the direct contact of the surrounding oil, the motor windings will not overheat as long as the coolant is at a reasonably lower temperature. Also, when



CROSS-SECTION of the pump shows both the gear pump and specially designed induction motor totally immersed in the cooling medium. Circulation of the oil to insure efficient transfer of the heat dissipated from the motor's rotor and stator surfaces is obtained by the skew of the rotor slots, the oil being pumped through the motor airgap. Also, by submerging both the pump and driving motor in the coolant, the need for running seals has been eliminated.

SHOULD THE OIL in the main piping system and heat exchanger be too viscous to flow freely because of low ambient temperatures, initial circulation is set up inside the pump housing. Oil is discharged through a ball-type relief pressure valve, a pressure equal to the relief pressure also being applied to the main coolant line. Thus, when the heat in the rapidly flowing secondary circuit has penetrated the rest of the system, the normal flow conditions occur. If the oil temperature reaches a dangerous level, a thermostat imbedded in the housing reservoir shuts off power to the motor.



Coolant Viscosity

the oil viscosity is lowered sufficiently to permit pump operation, the power input to the motor is reduced.

To take advantage of this "built-in" coolant heating arrangement, the pump is sealed within an inner housing, the annular space between the inner and outer housings being used as the recirculating or "priming" circuit. Circulation in the pump casing continues until the viscous oil in the main coolant circuit begins to flow. Then, the pump discharges directly into the system, initiating normal flow conditions throughout the circuit.

When the pump is used in conjunction with self-contained electrical or electronic equipment, the control circuit is designed to be completely automatic in its operation. The circuit is set up so that as soon as the flow in the main coolant line reaches a predetermined figure, an electrical contact on a flowmeter is closed. Closing of the contact then puts into operation the equipment to be cooled. This design prevent overheating of the equipment by acting as a built-in "starter," a factor of importance for critical military uses.

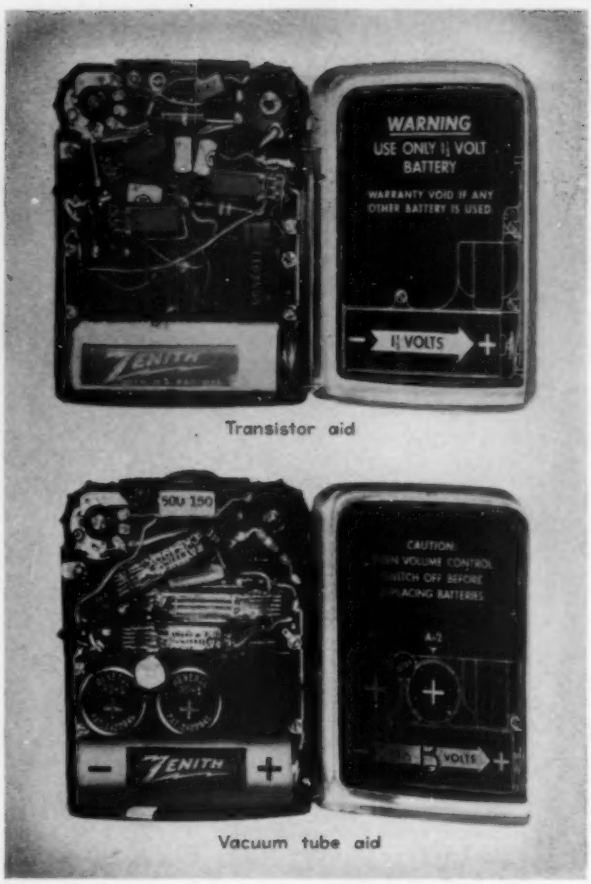
Hearing Aid— Transistor's First Consumer Product

In order to bring clearer hearing aid sound reproduction, marked operating economy and the convenience of fewer battery changes to the hard-of-hearing, Zenith Radio Corporation designed a new hearing aid incorporating junction-type transistors instead of conventional vacuum-tubes. Although this aid has much the same physical appearance as Zenith's older, vacuum-tube model, it utilizes an entirely new system of electrical circuitry that offers significant improvements in performance and economy.

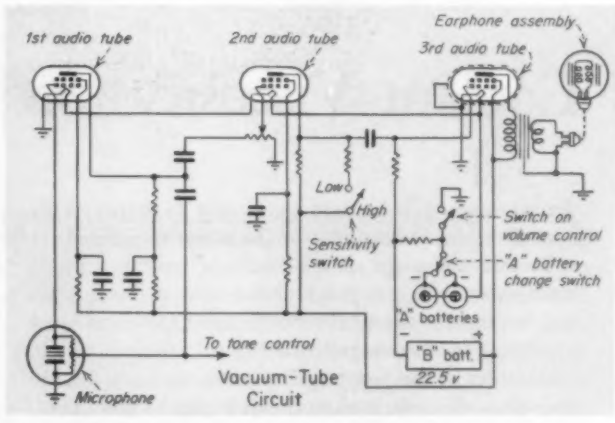
Substituting transistors, which have relatively low power consumption, for vacuum-tubes, which require a relatively large power input, permits an ordinary 15 cents dry cell to replace the former complement of a $1.15 "B" battery and 32 cents mercury "A" cell. In the transitorized model, the one battery lasts a full month in average use, making the monthly operating cost about 15 cents compared to $4.50 to $9.00 for the vacuum-tube model.

One example of the new circuitry is the transformer coupling of the transistors instead of a conventional resistance-condenser network, with the use of transformers to magnetically join the transistors giving a more efficient and flexible method of matching impedances. Also, proper voltage loading can easily be maintained, resulting in less voltage loss in the circuit. This factor, in turn, insures more voltage on the transistor collector element. When related to battery life, it means that satisfactory operation can be maintained even though battery deterioration lowers the starting voltage to one-half of its normal rating.

Since the mercury "A" cells lose power abruptly without warning, the older vacuum-tube model included a spare "A" battery with an external battery changeover switch. Now, because of the sustained service life of the 1½ v cell which replaces both the "A" filament supply battery and the 22½ v "B" battery, the reserve battery switch and its associated circuit are eliminated.



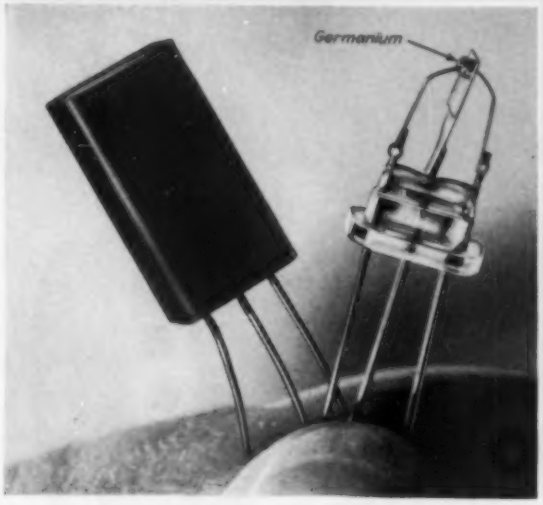
NEW TRANSISTOR and older vacuum-tube hearing aids. Since redesign was based on using as many existing components as possible, there is no perceptible change in size or weight. Contrary to much "popular" transistor conception, if the aid had been completely designed from the case up, the resulting model would still be about the same size.



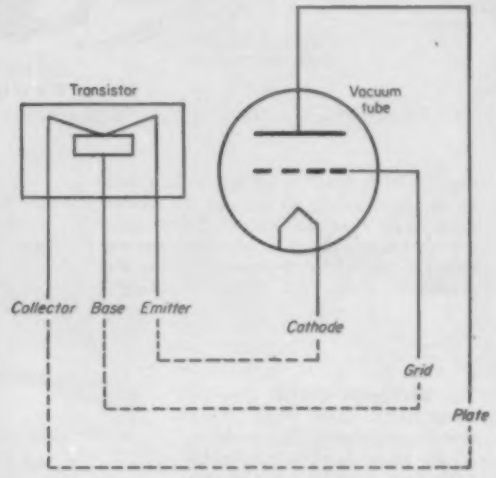
VACUUM-TUBE and transistor circuits for old and new hearing aids. Initial power consumption of vacuum-tube model is 35

Comparison of Principal Parts of Transistor and Vacuum-Tube Hearing Aids

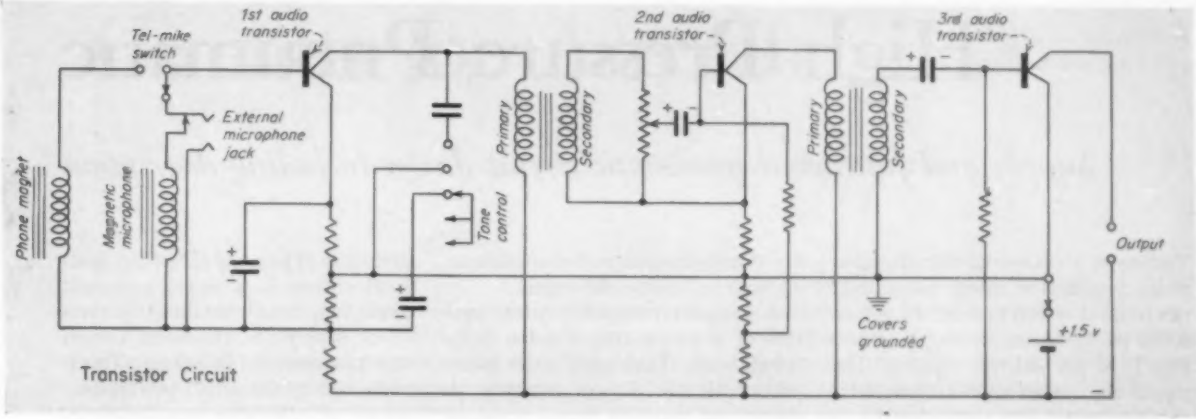
Hearing Aid	Microphone	Amplifiers	Coupling	Power Output	Batteries
Vacuum-tube type	Hi-impedance (Crystal or Ceramic)	Vacuum tubes	Resistor-condenser networks	Thru step-down transformer	"A"-filament supply "B"-22½ volt supply
Transistor type	Lo-impedance (magnetic)	Junction-type Transistors	Transformers	Directly to earphone	1½ volt cell



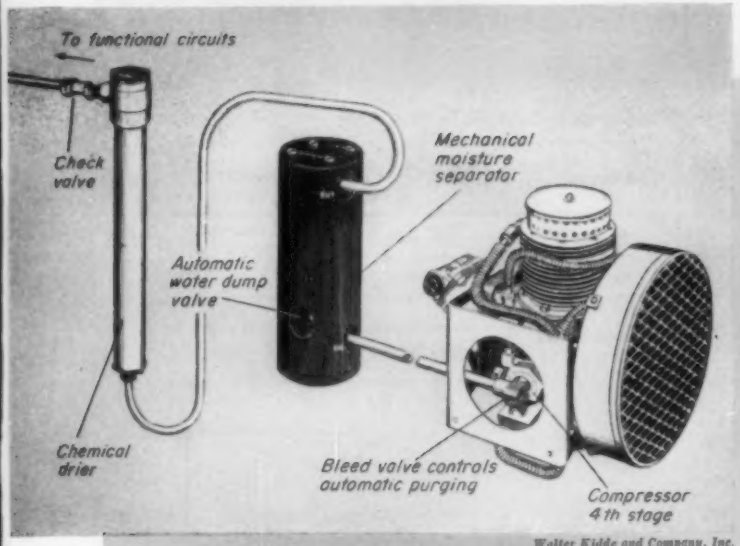
JUNCTION-TYPE TRANSISTORS, the one at the right being the element before hermetically sealed in a plastic case as shown at the left. Units as illustrated in picture are primarily being used in low power consumption applications. Biggest limiting factor to larger power usage is the problem of dissipating the heat generated.



WHEN OPERATING as a grounded emitter circuit, a transistor can be simply compared to a conventional vacuum-tube. The base functions similar to the tube's control grid; the emitter as the cathode; and the collector as the power output source of tube plate circuit. Transistor power requirements are low since no heater power is needed.



milliwatts, transistor unit draws only 6 milliwatts. Use of transformer coupling in new circuit, besides giving a better impedance matching between transistors, assures correct loading with the low d-c resistance in the collector circuits.



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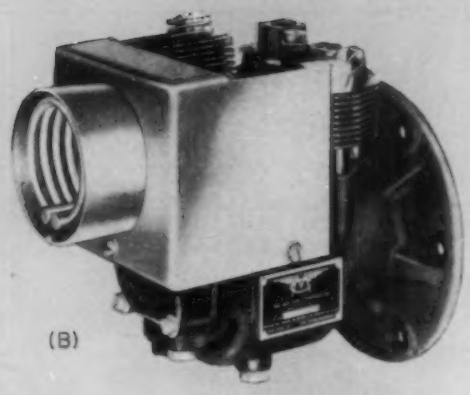


M. C. Manufacturing Co.

Fig. 1—High pressure air can be supplied by air compressors to operate mechanical components from sea level to 50,000 feet. Mechanical and chemical separators remove 99.6 percent of the moisture from the air before it enters the functional circuit.

Walter Kidde and Company, Inc.

Fig. 2—Typical aircraft type air compressors. Four stage motor driven compressor (A) requires 3.5 hp at sea level to supply 4.0 cubic feet of free air per minute at 3,000 lb per sq inch. Engine driven unit (B) supplies 1.8 cfm of free air at sea level at 3,750 rpm.

High Pressure Pneumatic

Supply and functional pneumatic circuit design including description

THE BASIC CONCEPT of aircraft pneumatic systems is to charge storage bottles to rated system pressure (1,500 or 3,000 psi) from an air supply circuit, Fig. 1, of low delivery capacity. The stored air is then used at flow rates varying from 1.0 to more than 80 lb per min for intermittent duty applications such as landing gear and bomb bay door operation or for continuous use such as, windshield wipers.

A complete pneumatic system consists of a supply circuit and a functional circuit. The supply circuit incorporates all the devices necessary to charge and maintain system pressures while the functional circuit includes the equipment needed to perform a given task. There can be several functional circuits in a single pneumatic system, but, in such instances, the number of supply and functional circuits must be maintained in balance. This is established by the design performance criteria of allowable compressor recharge time between each operation of the equipment of the system.

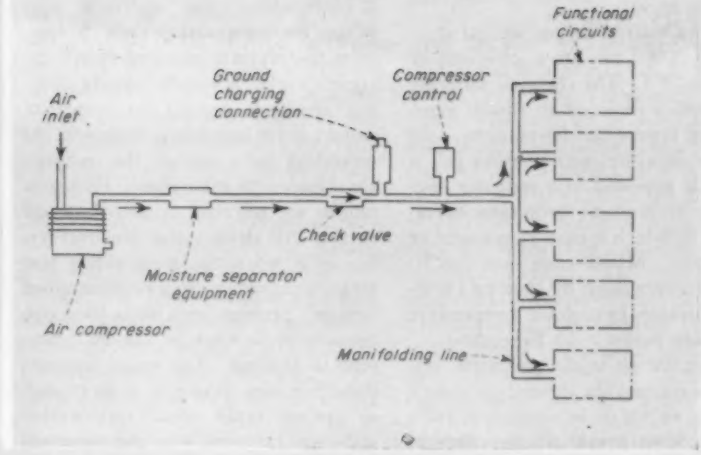


Fig. 3—Schematic of a supply circuit. Ground charging connection allows pressurization of the functional circuits without using the aircraft compressor.

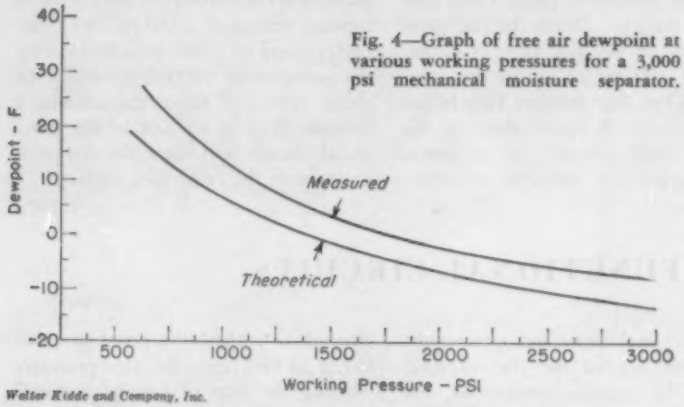


Fig. 4—Graph of free air dewpoint at various working pressures for a 3,000 psi mechanical moisture separator.

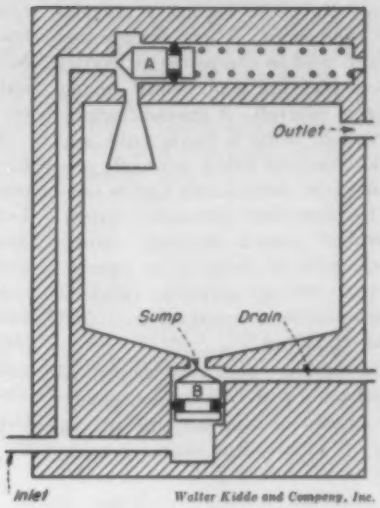


Fig. 5—Schematic of a 3,000 psi mechanical moisture separator. Temperature of air entering separator is a minimum of 15-20 F below maximum ambient value of 180 fahrenheit.

Circuits for Aircraft

PAUL L. BRADY
Consolidated Vultee Aircraft Corporation

and use of equipment. Functional applications are shown.

SUPPLY CIRCUIT

A typical supply circuit is illustrated in Fig. 3. Air flows from the compressor through the moisture separator equipment and check valve, and then past the compressor control into the manifolding. The latter interconnects the several functional circuits as well as other supply circuits in the system.

Compressors, Fig. 2, are rated on outlet port air flow in terms of pounds of air per minute or cubic feet per minute. The cfm rating is based upon standard sea level pressure of 29.92 in. Hg and standard temperature of 59.9 F. Lightweight air compressors, now in production, suitable for aircraft installations have a capacity of 1.5 to 4.0 cfm (0.115 to 0.305 lb of air flow per minute). This low capacity range limits the pneumatic system to intermittent duty operation except for small-demand functions such as windshield wiper operation.

The compressor, less drive, weighs from 11.0 to 17.0 lb. It has a lubrica-

tion system consisting of oil tank, pump and filter, and can have a cooling fan, and a filter at the compressor inlet port. In the event the compressor is operated at high altitudes, the inlet port is normally connected to the aircraft cabin pressurization system or jet engine bleed air takeoff.

Heavy duty commercial compressors, having a capacity of 15 cfm or more, are often used for equipment check-out operations, thus conserving the service life of the more expensive aircraft-type compressors. These compressors are also used to charge the air bottles to peak pressures at prescribed ground charging intervals. A ground charging connection, using a check valve and quick-disconnect fitting, is usually provided in the manifolding line to service the complete pneumatic system. Individual ground charging connections, similar in design to an automobile tire valve, are sometimes provided at each functional circuit for individual circuit check-out.

The moisture separator consists of a mechanical and a chemical assembly. The amount of moisture that air can carry in vapor form varies inversely with the pressure, Fig. 4. As air under the specified ambient conditions is pressurized, a portion of the vapor is forced out of the vapor state into the liquid state. It is this condensed liquid that the moisture separator removes mechanically. High pressure pneumatic systems usually require that the air have a free air dewpoint of at least —65 F and that the dewpoint must be accomplished starting with a free air condition of 100 F and 100 percent relative humidity. Mechanical separators will remove enough moisture to allow operation at an ambient temperature as low as —10 F. A chemical separator will remove the remaining air moisture to permit equipment operation at ambient temperatures of —65 F or lower.

The design of the mechanical drier, Fig. 5, is based upon removing water from compressed air by centrifugal action. Air enters the separator with a swirling motion that causes suspended particles of moisture to be thrown to the walls of the chamber and collect in the pump. As shown, air enters the inlet port and exerts a pressure on valve *A*. When the pressure builds up to 900 psi nominal, the valve opens, allowing moisture laden air to swirl through the chamber, release the suspended particles of moisture, and then pass the dry air to the chemical separator, by way of the outlet opening.

The air leaving the mechanical separator at 3,000 psi has a dewpoint of about —10 F. The chemical moisture dryer uses a desiccant to adsorb moisture and lowers the dewpoint to —65 F. The desiccant, such as silica gel, is normally provided in a cartridge suitable for 50 hours of compressor operation, after which it must be replaced or reactivated. Maintenance costs can be held to a minimum by limiting chemical separators to ambient temperature conditions below —10 Fahrenheit.

When the air in the pneumatic system has reached the desired pressure a pressure switch or an unloading valve located down stream of the chemical drier shuts off the compressor and activates an automatic bleed valve that unloads the line. When the line pressure drops to 400 psi, valve *A* closes, trapping 400 psi of air in the separator. When line pressure falls below 150 psi valve *B* opens allowing the trapped high pressure air to purge the separator of collected moisture.

The compressor control is a pressure-operated switch, for a motor driven compressor, or an unloading valve for a continuous engine operating unit. When the compression cycle is complete the pressure operated switch energizes a relay of suitable current carrying capacity to shut-off the compressor motor; or for continuous operation, the unloading valve relieves the compressor cylinders to atmosphere. Hydraulic motors use solenoid operated shut-off valves. All devices start the recharging cycle when the manifolding line air pressure reduces to a predetermined "cut-in" pressure and stops the compression cycle when a "cut-out" pressure is reached. The range between these pressures should be great enough to prevent rapid on-off cycling that will cause excessive wear and abnormal temperatures in the motor. A 1,500 psi system for aircraft can have a cut-in pressure setting of 1,350 psi and a cut-out pressure of 1,550 psi. By locating the compressor control between the check valve and functional circuits, a pressure drop in any one of the functional circuits will cause the compressor to start the recharging cycle.

FUNCTIONAL CIRCUITS

A functional circuit incorporates the equipment needed for the intended service. In aircraft installations, the circuits consist of an air bottle, a pressure reducer, control valves, and actuator.

Air Bottle: The air bottle stores sufficient energy for one or more operations of a mechanism without benefit of an air compressor. It is normally constructed of steel with sufficient strength to withstand a proof pressure test of 1½ to 2 times the rated pressure. To stop the flow of foreign material into control valves that are located downstream, a standpipe is used that extends from the inlet port to the approximate center of the bottle with the outlet port adjacent to the inlet port. The air must then flow into the bottle through the standpipe and make a 180 degree turn before entering the outlet port. The change is direction of air flow combined with the sudden loss in velocity as the air leaves the standpipe and enters the bottle chamber protects the balance of the system from foreign matter.

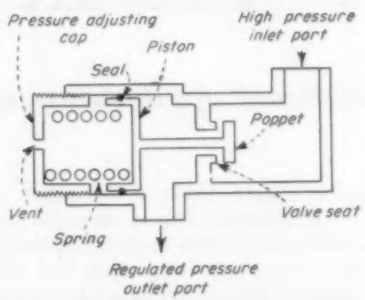


Fig. 6—Schematic of pressure regulator. Pressure adjusting cap varies poppet valve setting, regulating outlet pressure to demand of actuator. Regardless of air pressure at inlet, outlet pressure is constant.

Landing gear tubular structure have been used for storing supplemental supplies of compressed air in place of bottles. This feature takes advantage of existing structure and saves weight.

Pressure Regulator: This valve reduces the rated storage pressure to the equipment operating pressure. The regulator is basically a pressure sensing device that uses a spring-loaded dia-

phragm or piston to operate a valve, as shown in Fig. 6. As the downstream pressure approaches the valve setting, the poppet moves toward the seat. Further increase in downstream pressure causes the poppet to close; a decrease pressure opens the orifice between the poppet and valve seat. Thus, air to the actuator is controlled to a relatively constant pressure within the tolerances of the valve which is a function of pressure drop, valve mechanical friction and other factors. The valve manufacturer must meet two design conditions: 1.) Cut-off pressure—no flow through the valve—maximum downstream pressure rating and 2.) Rated pressure at full flow condition.

Control Valves: Control valves can be operated manually, by pressure, by electric solenoids or electric motors. The manual valve can vary from the simple needle or shut-off valve to the more complex configurations used to control the sequence of machinery operation by mechanical control of the valve. The pressure operated valve is similar to the regulator in that the system pressure is sensed. However, the control valve will change the direction of air flow as a result of poppet valve selection rather than controlling pressure of the system. The electric solenoid and motor operated valves are used to select the operation of pneumatic devices located in a position remote from the operator. Both valve configurations can be similar, except for their actuation. Motor operation is preferred where a time delay is desired after the manual switch is selected. The solenoid valve will operate within 1/100 of a second.

Actuating Device: This piece of equipment may be linear or rotary in motion. Application of rotary motors have been hampered to date by the slow development of suitable lubricants for the rotating components without frequent servicing and collection of excess lubricant around the exhaust port. The linear actuator, by contrast, has been used for long periods without servicing. The present method of lubricating cylinders is to provide wipers, impregnated with grease, on either side of the air seals.

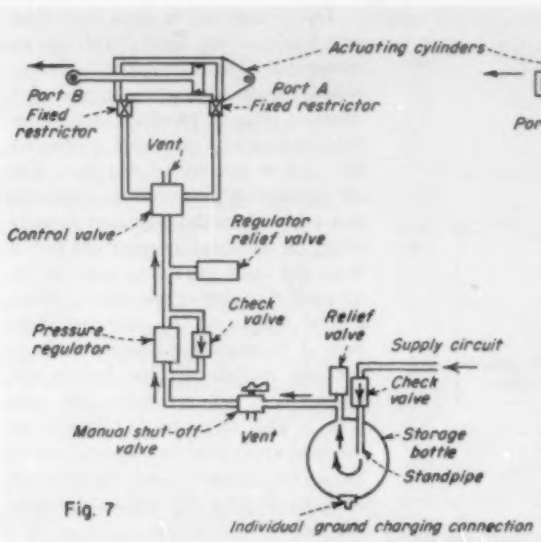


Fig. 7

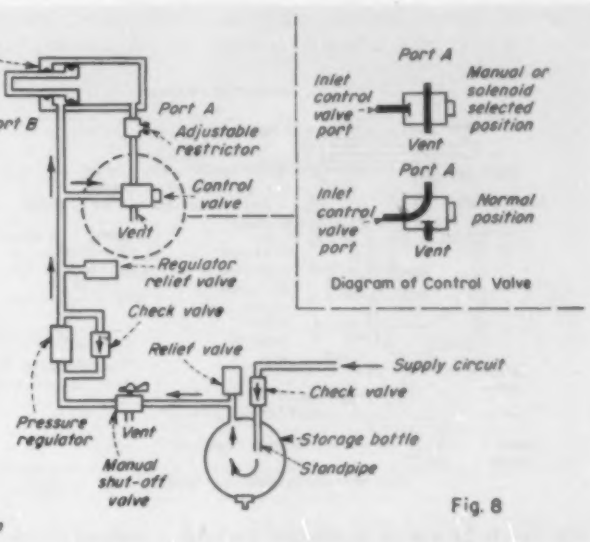


Fig. 8

Fig. 7—Basic functional circuit. Position of inlet and outlet ports of storage bottle allows foreign matter or water left in compressed air to settle to bottom of bottle and be drained.

Fig. 8—Modification of basic circuit using a two position valve. Normal position has pressure and cylinder port interconnected while selected position connects cylinder port to vent.

APPLICATION OF FUNCTIONAL CIRCUITS

Functional circuits are found in any number of forms. One of the simplest and basic circuits is illustrated in Fig. 7, and has been used in conjunction with lightly loaded actuating cylinders of approximately 1.0-in. bore and 2.0-in. stroke. For example, one application involves the operation of a flare chute door from a closed, latched position to an open position and return. The latches are operated by mechanical linkage tied to the initial motion of the cylinder. The door is held open by cylinder pressure.

Since the design criteria require several successive operations of this circuit without benefit of compressor recharging cycle, an individual air bottle is used. As shown in Fig. 7, the manifolding line from the supply circuit is connected to the air bottle via a check valve. The check valve protects the circuit from loss of air pressure in the event of manifolding line failure. The relief valve, indicated on the storage bottle, protects the circuit in the event of compressor control valve failure. Air flows from the bottle through a manual shut-off valve and pressure regulator past the regulator safety valve to the control or selector valve.

Two fixed restrictors are attached to the actuating cylinder heads. These restrictors control the actuating cylinder speed and reduce piston rod impact at the end of the cylinder stroke. The

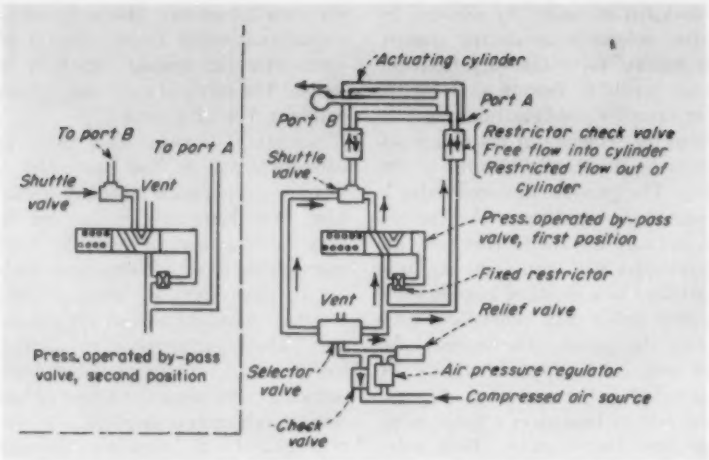


Fig. 9—For better speed control a by-pass valve can be added to the circuit. This precharges the actuator through port *B*. At a predetermined point the by-pass valve moves to the second position venting port *B* to the atmosphere.

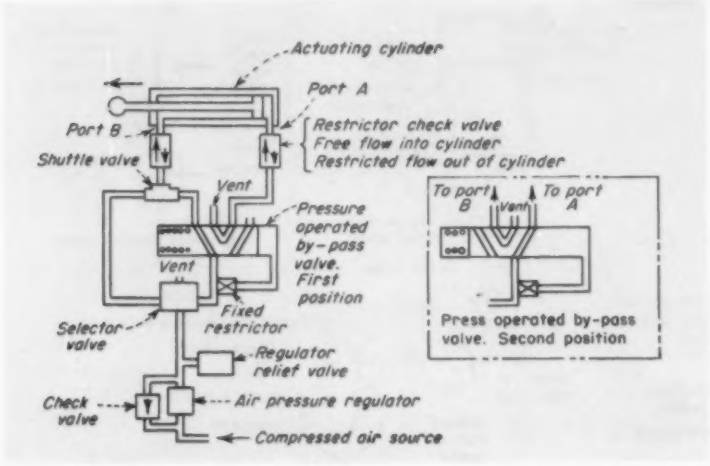


Fig. 10—To be sure of an adequate precharge a modified by-pass valve can be used. Original pressure buildup is to port *B*. At a predetermined point the by-pass valve moves, venting port *B* to atmosphere and connecting port *A* to pressure.

snubbing action and speed control are accomplished by a combination of air flow control and cylinder compression ratio. Careful cylinder design provides the greatest possible compression ratio by maintaining minimum residual volume at the end of the stroke.

The manual shut-off valve is provided for the convenience of maintenance personnel. The air supply can be shut off during servicing and adjusting of the mechanical linkage. It also protects against accidental operation of the circuit. The valve in the closed position simultaneously shuts off the air supply and vents the valves and actuating cylinder to atmosphere. Since the air pressure regulator allows flow only toward the cylinder after the air has reached the lock-out pressure, a check valve must be provided to vent the tubing and control valve when the manual valve is in the "off" position. This check valve and flow direction are shown adjacent to the pressure regulator.

The regulator relief valve prevents excessive pressure in the actuating cylinder and control valve in the event of pressure regulator failure.

The selector valve has three positions: neutral, door-open, and door-close. The neutral position blocks the air supply from the pressure regulator and interconnects both cylinder ports to atmosphere. The door-open position allows air pressure to flow to port *A*, and port *B* exhausts to atmosphere. The door-close valve position reverses the valve operation and air flow.

A modification of the simple circuit is shown in Fig. 8. The change is primarily in the control valve. This circuit has been used where a mechanism being operated must be held in one position by the pneumatic system without aid of latches.

The actuating cylinder is operated in the direction of the arrow as a result of differential cylinder area since the same pressure is applied to both sides of the piston head. The piston rod moves in a direction opposite to the arrow when the port *A* is connected to exhaust.

This circuit can be used in application where a time delay is a design requirement. The actuating cylinder residual volume connected to port *A* is made as large as possible. An adjustable restrictor is provided to control the air flow rate out of this port. The air pressure at port *A* is thus reduced to a value where the regulated pressure acting on the annular area of the piston head will cause the rod to move in the opposite direction of the arrow. Thus, a total weight of air removed from port *A* to reach the pressure balance for rod motion divided by the restrictor flow rate determines the time delay. The time delay increases as the load application in the direction of the arrow increases since the pressure at port *A* must be reduced proportionately.

There are many applications where highly loaded actuating cylinders require better speed control than is available in the basic circuit. For example, bomb door or landing gear door operation requires high speed with minimum impact at the end of the cylinder stroke. These doors are often aided during the opening operation by external loads in the form of air loads or "G" loads. Thus, deceleration or snubbing problems become more important. One circuit, utilizing a pressure operated by-pass valve, is illustrated in Fig. 9. The circuit incorporates restrictor check valves and a shuttle valve in conjunction with the normal functional circuit equipment.

This circuit precharges the cylinder at port *B* while the piston rod is traveling in the direction of the arrow.

When the selector valve is moved to the door-open position, air flows to ports *A* and *B*. When a predetermined pressure is reached, the by-pass valve moves to vent port *B* to atmosphere and simultaneously blocks the air entering the by-pass valve. Note that the air enters the actuating cylinder during the precharge cycle through a restrictor check valve in the "free" flow direction. Air leaves the cylinder in the "restricted" flow direction. As the actuating cylinder progresses toward the extended position, the initial air precharge is compressed. As the piston head approaches the cylinder head at the end of the stroke, the air pressure at port *B* increases sharply providing the necessary force to decelerate the mass.

The door is closed by selecting the control valve so that the air supply is directed into port *B* via the shuttle valve. Port *A* is vented to atmosphere. As the doors approach the closed position, pressure in the bomb bay cavity increases slightly, causing the doors to decelerate without additional pneumatic equipment.

One limitation exists with the by-pass valve. The pressure is applied to both ports of the actuating cylinder during the precharge phase of operation. This starts the piston rod to move. In the event the load moves the piston rod faster than the air can flow through the selector valve orifice, pressure may not build up great enough to provide adequate speed control. To overcome this possibility, a second type of by-pass valve is used, Fig. 10. This valve directs air toward Port *B* until pressure builds up to a predetermined value, then directs pressure to port *A*, second position. Note that in both valves a restrictor is provided in the pressure sensing line.

It has been found by experience that pressure wave propagates through the tubing immediately after the selector valve is operated. The value of this pressure wave can be as great as 50 percent of the regulated pressure setting. Pressure sensing valves set at lower values will be sensitive to this pressure wave and cause malfunction.

Wave propagation has been used to advantage in some pneumatic system applications. Fig. 11 illustrates the relationship between two uni-directional actuating cylinders used in an emergency system. The design criteria requires that the smaller unlatching cylinder be operated before the larger "link" cylinder moves through its stroke. When the circuit's control valve is operated, the air passes first to the unlatching cylinder then to the "link" cylinder. The pressure wave provides the necessary sequence of operation. This system is not absolutely positive in operation since the unlatching cylinder might jam and cause malfunction of the entire circuit. However, this condition is considered a failure on a failure, and therefore, not a risk. The "link" cylinder is unique in design because it incorporates a lock device to maintain a fixed length between lever arm pivot points before operation. Application of air pressure unlocks as well as extends the cylinder.

Continuously running machinery, such as windshield wiper actuators, present slightly different problems that relate to the balance between the air flow demand and the compressor supply. In the event the compressor supply is greater than the demand by a large margin, rapid cycling between the compressor "cut-out" and "cut-in" will occur. This condition may be detrimental to the motor of the compressor.

The period of time between the "cut-out" pressure and the "cut-in" pressure can be increased by providing an air bottle. The time period can be further increased by placing a pressure-operated shut-off valve in the circuit as illustrated in Fig. 12. This valve allows the air bottle pressure to drop from the maximum storage pressure to the wiper actuator operating pressure which may be 100 psi. The valve then moves to interconnect the bottle with the manifolding line. The manifolding line pressure then drops to the compressor control "cut-in" setting, causing the system to be recharged.

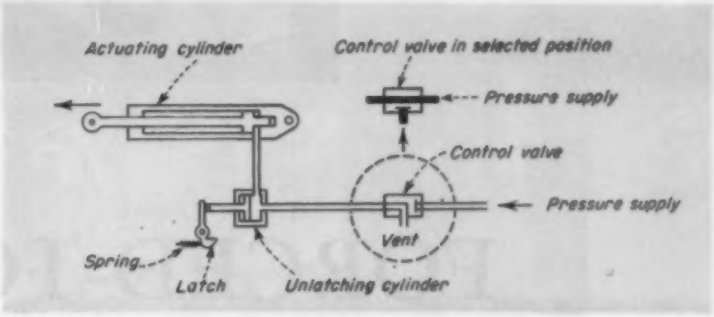


Fig. 11—System operation by using wave propagation to unlatch and open door.

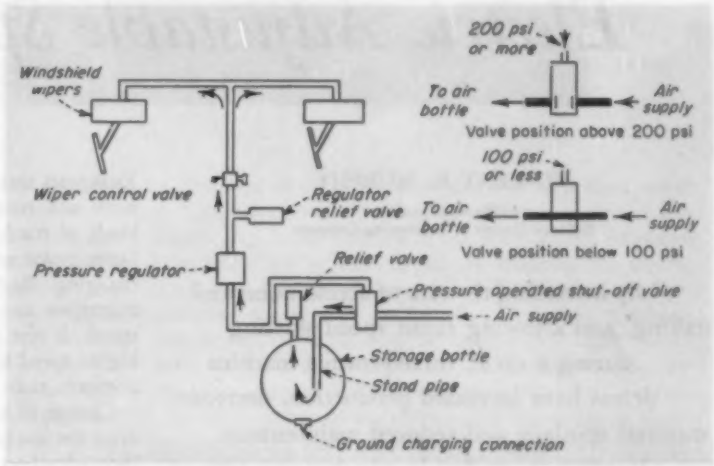
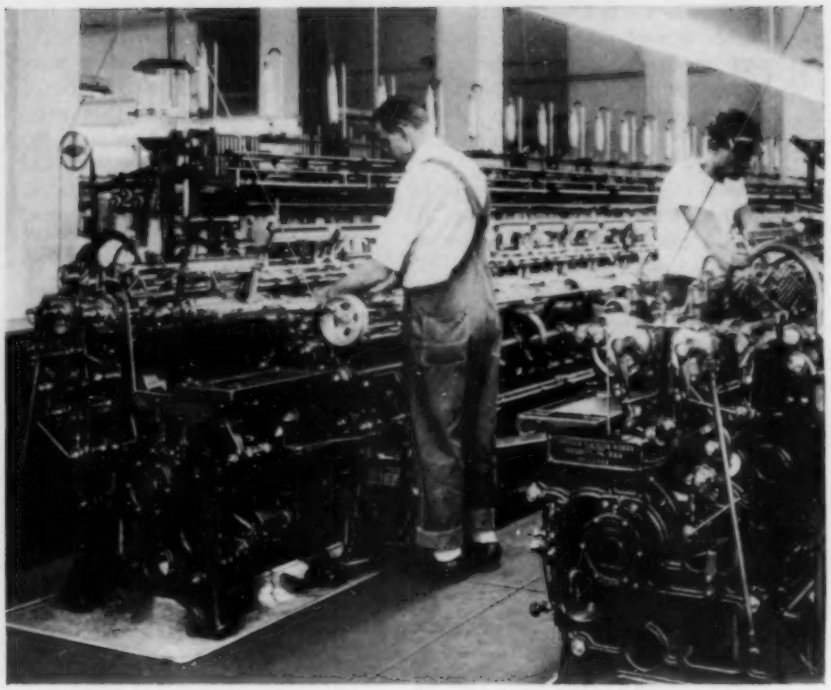


Fig. 12—Continuous operating component run by a pneumatic system. Normal valve position allows system to be operated by storage bottle pressure. When pressure drops to a predetermined value valve opens refilling bottle.

Fig. 1 (Left)—Typical example of a low horsepower application of forced-torque drive. This full fashioned hosiery knitting machine is driven by 5 hp adjustable speed motor and turns out 30 stockings in 35 minutes with minimum required maintenance.

Fig. 2 (Right)—Automobile body press powered by 500 hp forced-torque adjustable speed drive. Former presses of this type used a constant speed alternating current motor driving through a crank mechanism with flywheel, brake and clutch.



FORCED-TORQUE

Electric Adjustable Speed Drives

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Application Engineer
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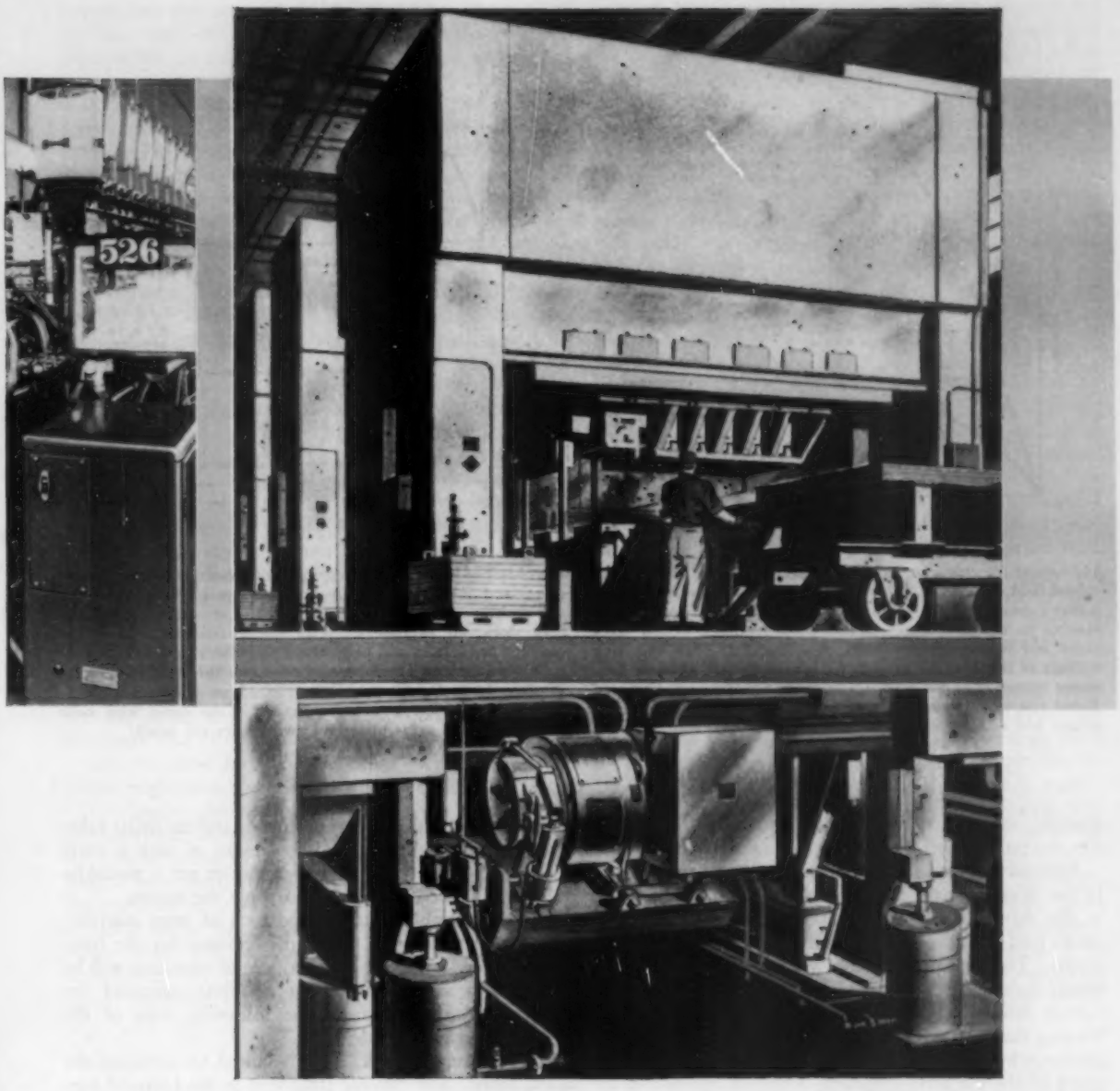
By increasing the rate of acceleration and braking, and allowing rapid speed shifting during a cycle, forced-torque machine drives have increased production, decreased material spoilage and reduced maintenance.

Here's how to decide whether this type of drive can improve the performance of a particular machine and if so by how much.

THROUGH THE APPLICATION of a new type electric motor drive and control system the production rates of certain kinds of machines can be increased. This is achieved by faster motor acceleration and braking and automatic speed changing. By this means each step in the series of machine operations can be performed at the highest permissible speed. If one portion of an operation permits significantly higher speed than another, the operation can be split into portions, each running at its highest practical speed.

Change of speed is so rapid that it is often possible to drive the machine at a number of successive speeds each of short duration and of widely different magnitude. For example, the time required for the motor to go from rest to full speed of 750 rpm is of the order of a half a second. This often makes it desirable to change speed even though



the running time at the changed speed might be relatively brief compared to total cycle time.

Indicative of the results that can be achieved, this new drive and control system was applied to a 500 hp motor driving a triple-action press for forming parts of auto bodies, Fig. 2. In operation for more than two years, production rate was increased and down time for repairs was reduced. The increased production rate resulted from two factors: a 50 percent decrease in scrap (from 10 to 5 percent of total production because of speed changing and improved speed control during working portion of cycle), and speed changing to higher speeds during nonworking portions of the cycle caused a shorter total cycle time. Comparable results have been obtained on other machines; for example, planers, automatic conveyors and press feeders.

This type of drive is not confined to high horsepowers. A 5 hp drive on hosiery knitting machines has given good results, Fig. 1. In addition to the much higher production rate, there was a decided gain in reducing the machine down time. Because of smoother running, repairs were fewer and there was no time out for adjusting brakes, clutches or mechanical speed shifting systems because these are not used. This feature is important since down time on these machines costs the manufacturer about 30 dollars per hour.

A characteristic of the drive is that the motor is directly coupled to the main drive shaft, thereby not requiring a brake, clutch and very often a flywheel. Braking and speed control are effected electrically, with no wear and minimum shock. However, some machines must be equipped with a small brake to hold a certain stationary position; for

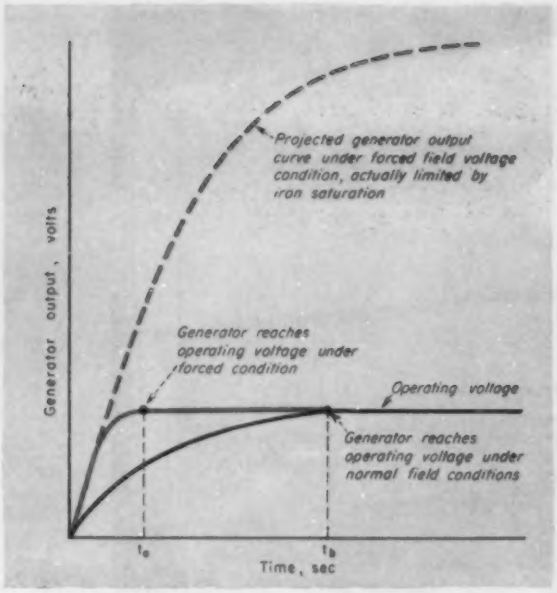

Generator output, volts
Projected generator output curve under forced field voltage condition, actually limited by iron saturation
Generator reaches operating voltage under forced condition
Operating voltage
Generator reaches operating voltage under normal field conditions
t_a
t_b
Time, sec

Fig. 3—Voltage-time curves for generator under normal and forced field conditions. With high field voltage generator output follows projected curve until just before generator voltage reaches its normal value. At this point regulator action takes place and field voltage is reduced to normal. Thus operating voltage is reached in time t_a. With normal field voltage, generator output does not reach the operating voltage until time t_b. Rapid rise in generator voltage causes rapid increase in motor torque and acceleration allowing fast speed changing.

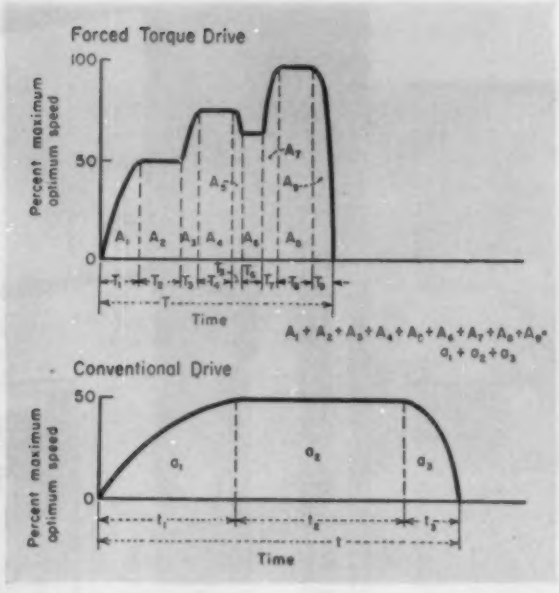


Fig. 4—Speed-time curves for the same machine using conventional and forced-torque drives. With the conventional drive the machine starts, runs through the cycle at constant speed and then stops, all in time t. With the forced-torque drive the machine accelerates and stops faster and also takes advantage of speed changing to obtain optimum speeds throughout different portions of cycle. This is accomplished in a shorter time T. Since the distance of machine travel is the same with both drives, the total areas under the two curves are equal.

example, as required when mounting dies in a press.

Adjustable motor speed is obtained by the Ward-Leonard principle. That is, the driving motor is d-c with its shunt field across a separate voltage supply. The armature of the shunt wound d-c motor is across an adjustable voltage constant speed d-c generator. Varying the output voltage of the d-c generator by field control changes the speed of the d-c driving motor.

The rate of acceleration of the driving motor from one speed to another depends largely on how fast the generator voltage can be made to build up. In Fig. 3 is shown the time-voltage curve of a typical generator under normal starting conditions and under the condition of "forcing" wherein approximately eight times normal field voltage is instantaneously applied. When the generator output voltage reaches its normal level, regulator action immediately reduces the high field voltage to the proper value. Thus the forcing action reduces the time required to reach the operating point.

The intensified "starting" voltage is called the forcing voltage. Usually it is four to eight times the normal running voltage. In this forced-torque system, the forcing voltage is applied automatically whenever the controls call for increased motor speed. The electrical system is so designed that it automatically and accurately controls the voltage across the motor so as to obtain maximum permissible accelerations and yet avoid electrical damage or undesirable mechanical shock. The "secret" of the whole system is the attainment of the voltage changes almost instantaneously, as will be described.

Changes to lower speeds are obtained by regenerative braking. This is not only much faster than mechanical braking but is more accurately controllable and does not get out of adjustment.

As is to be expected, a forced drive system costs considerably more than a conventional a-c motor and control. Therefore before going to appreciable expense of detailing the engineering application of the system, a study should be made to determine the possible increased production and other savings obtainable and the dollar value thereof. The results of such a study will show whether or not it would be profitable to apply the system.

In the operation of every machine, the total time required for the completion of a cycle of operation will be the sum of the time consumed for each of the following steps of the cycle.

1. Time required to accelerate the motor from zero to the balanced running speed of the first operation.
2. The balanced-speed running time during the first operation.
3. The time required to change the speed from that of the first operation to that of the second operation.
4. Balanced-speed running time for the second operation.
5. Time consumed for successive speed changes and balanced-speed running, including speed reversals, as stated in 3 and 4.
6. Time required for stopping the machine.

In certain machines there will be only starting, running and stopping. In others, the series of operations per-

formed and the number of different speeds desired may be numerous.

Many machines as now driven perform certain successive operations at the same speed although some of the operations could be performed at a much higher speed. A single running speed might be used because with a conventional drive it would be impractical or impossible to change the speed rapidly enough for successive operations. The simple crank type draw press with a conventional motor drive is an example. In the operation of such a press the slowest required speed is that when the descending die is about to touch the sheet. The speed can then be increased somewhat to the end of the down stroke and further increased when the die begins to withdraw. Then the balance of the return stroke and the first part of the down stroke can be at high speed. To attempt to obtain this optimum speed cycle by mechanical means would be impractical. Therefore in conventional press drives the running speed is determined by the slowest speed required in the cycle of operations.

Whatever the machine may be, the first step in the analysis is to make a time-speed curve to determine whether or not this new forced-torque drive system might show substantial savings.

To visualize the possible increased productivity in driving a machine with this type of system, Fig. 4 shows hypothetical time speed curves illustrating the operation of a machine with conventional motor drive and a forced-torque drive. The conventional drive represented here runs at a constant speed while the forced-torque drive takes advantage of the speed changing possibilities and runs at the optimum speed for each portion of the cycle.

Areas under the various sections of the curve are the measure of the corresponding distances the machine moved. Thus a_1 in the lower graph is the distance (revolutions, length of stroke, angular rotation, etc.) that the machine "displaced" during the starting period when the speed went from zero to 50 percent balanced running speed in time t_1 with conventional drive. Similarly, the machine then continues running at 50 percent speed for the time t_2, at the end of which the machine is brought to a stop in time t_3 and the cycle is completed. This 50 percent speed represents the maximum *constant* speed at which this particular machine can be driven and is limited by the maximum allowable speed for the critical portion of the work cycle; say when the die contacts the work in a press. However, other portions of the cycle can operate at various other speeds up to 100 percent speed.

The upper curve, showing the same machine driven by a forced-torque drive, takes advantage of this fact and changes speed three times during the cycle, each speed being the optimum for the particular portion of the cycle. This is practical since the forcing action and regenerative braking allows almost instantaneous starting, stopping and speed changing. The area under the upper curve equals the sum of the incremental areas, A_1, A_2, A_3, A_4, A_5, A_6, A_7, A_8 and A_9, which is also equal to a_1 plus a_2 plus a_3 on the lower curve. That is, the distance of machine travel, as measured in revolutions or other displacement units, is the same for both curves. The total time for the cycle when using forced voltage acceleration, regenerative braking and speed changing will be T. Hence the fraction $T/(t_1 + t_2 + t_3)$ will be a measure of the ratio of total cycle time for the operation of the machine when driven by a forced-torque drive to the total cycle time when driven in the conventional manner. The percent to be gained is:

$$\text{Percent gain} = \frac{(t_1 + t_2 + t_3) - T}{t_1 + t_2 + t_3}$$

The production ratio will be:

$$\text{Production Ratio} = t/T$$

From the chart it can be seen that the reduction in cycle time stems from the time required for starting and stopping, that is, the reduction in time t_1 and time t_3, especially the time t_1, and in the reduced time for portions of the cycle where higher speeds are used. The gain in production would be greatest for a cycle wherein the machine with conventional drive is started, reaches balanced running speed and is immediately brought to a stop. That is, there is no constant speed portion or portions of the cycle. An example of this is in winding small sized rolls such as wax paper for domestic use where the drive is accelerated and immediately decelerated. The least gain, zero percent, is when the machine is started, comes up to speed and is never stopped. In this application there is one optimum speed for the whole cycle. This of course is only a theoretical condition but it indicates, Fig. 5, that the amount of increased production is greater as the

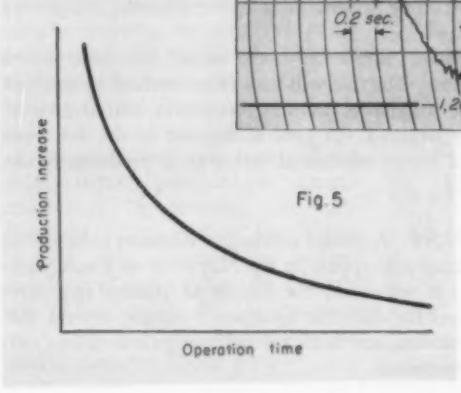


Fig. 5

Fig. 5—Curve represents production increase obtained by using forced-torque drive plotted against total operation time for condition where only one operating speed is required and there is no speed changing. As cycle time decreases, production increases with the maximum increase occurring under a condition of acceleration and immediate braking.

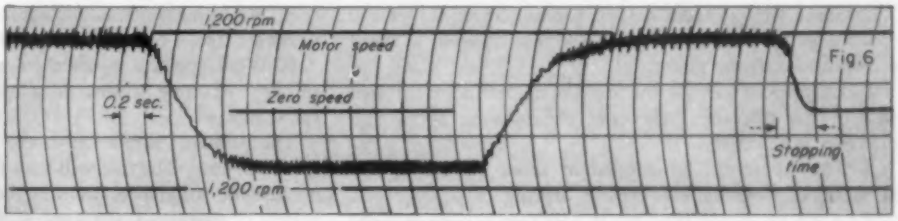


Fig. 6

Fig. 6—Oscillograph record of 35/70 hp motor driving a 48 in., 16 ft open side planer through 4 to 1 gearing. Plot is of speed against time. Unit reverses in about 0.8 sec and can be stopped in 0.3 seconds.

length or duration of the operating cycle decreases, and as the number of different optimum operating speeds in one cycle increases.

It is recognized that there are factors in addition to speeds that limit the productivity of a machine. It may be humanly or even mechanically impossible to feed the machine as fast as it might be operated. The material being processed by the machine might not permit faster speeds. For example, some textile machines have their speed limited by thread breakage. All such considerations must be taken into account when analyzing the drive.

To analyze the operation of a machine for the purpose of determining what might be gained with respect to greater machine productivity by adopting a forced-torque drive, the first step is to construct the actual time-speed curve for every step in the cycle of operations of the machine as driven conventionally. Starting and stopping curves should be obtained by testing the machine under running conditions. If the machine is still on the drawing board, the speed curves must be calculated or estimated from comparable drives.

From the plotted time-speed curves, as in Fig. 4, the area under each section of each curve (displacement) and the elapsed time for each portion of the cycle is obtained. Where work is done during a period of acceleration, the approach must be modified to take account of this factor.

The speed-time curves for a machine can be determined by calculating the acceleration and deceleration time of a system from known values of inertia and the available torque from the electrical equipment. The machine cycle used must reflect all the advantages of going to higher speeds in the process whenever mechanically allowable. Tentative figures on the gain in machine production that might be obtained by changing to a forced-torque drive can be obtained directly from the curves.

The reason why the gain figure will be only tentative is because there are a number of other possible factors involved which might greatly increase the gain in production or perhaps decrease it. For this reason it is necessary to study carefully each step for the cycle of operations to determine other possible changes and factors such as increasing the speed of certain portions of an operation.

Every idling portion of the cycle presents possible time savings by speeding the machine for that section of the cycle only. Examples are return strokes as on planers and presses, rapid traverses on lathes, idling time on screw machines. Percentage-wise these seemingly insignificant steps often offer the greatest gains.

In some machines running with conventional drive, attempts to change speeds mechanically result in a theoretically functioning machine that practically cannot be kept in operation because of wear and shock. Hosiery knitting machines are an example. Great gains in knitting machine productivity have been obtained by applying electrical adjustable speed drives in which the speed changes with great rapidity and over a wide range, and in which required maintenance is at a minimum.

In addition to increased productivity, there are other economic gains to be obtained through the application of forced-torque drives. Machines that run at constant driving speed are usually geared to run at the highest possible constant speed. This speed tends to be too great for those portions of the cycle that should operate at slowest speed. For example, in the draw press operation, at the moment the die makes contact with the sheet the speed should be slow. A high speed would tend to shift the sheet, causing work spoilage. To run the machine slower would reduce production correspondingly. Therefore the practice is to accept a certain amount of such spoilage as being necessary. But with a forced-torque drive it is simple to reduce the speed for the short duration while the die is making contact with the sheet. Work spoilage is correspondingly reduced.

Another factor in favor of the forced-torque drive is reduced maintenance. The rapid accelerations and controlled speed changes are cushioned throughout. The driven machine requires no brake or clutch. Hence there is no cost for maintenance of these items. And of perhaps more importance, there is no downtime required for adjusting clutches or brakes.

. . . Summarizing, the forced-torque drive has the following characteristics and economic advantages:

1. Speed will go from zero to running speed, say 1,200 rpm for a 75 hp motor in less than 0.6 seconds, or in about 6 revolutions of the motor.

2. Each speed can be the maximum optimum for that step of the machine cycle since the running speed and direction is selective.

3. The motor can be stopped in about 0.4 sec or less by means of a regenerative type of braking.

4. A 35 hp motor running at 750 rpm can be stopped and reversed to 750 rpm in less than 0.7 seconds.

5. Starting and stopping is cushioned because the acceleration rates are automatically controlled.

6. It is feasible to jump from one speed to another almost instantaneously and thereby greatly increase the productivity because forcing voltage acceleration gives extremely rapid speed changes.

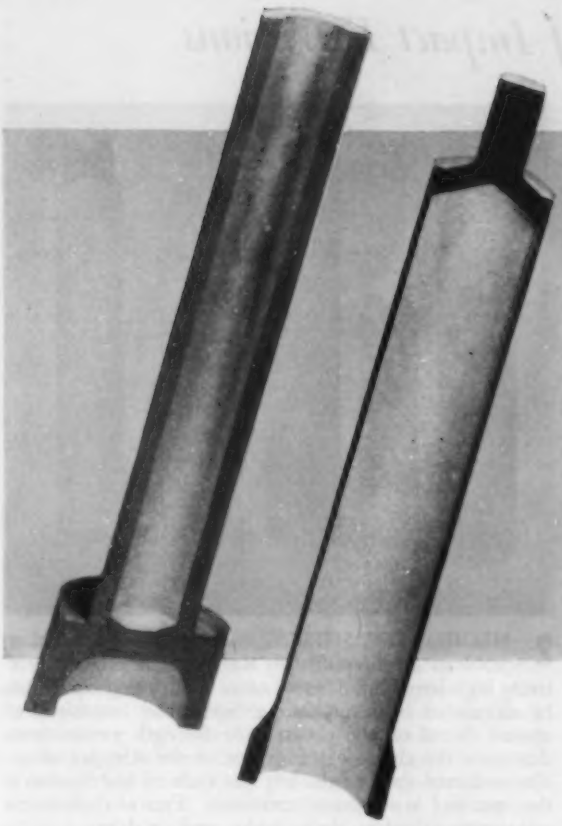
7. The driven machine requires no brake or clutch, thereby saving their first cost, and the cost of their maintenance and avoiding down time loss when clutch or brake needs adjustment.

8. Machine maintenance costs less since the drive is much smoother than a conventional one with clutch and brake.

9. Work spoilage is often considerably less when using this type of drive because of smoother running and precise speed control.

The principal limitation to the use of this drive system is its first cost. The cost will vary from machine to machine because of differences in the horsepower and degree of complexity required. In general the cost of the drive can be justified where substantial increases in productivity can be achieved.

EDITOR'S NOTE: A second article that discusses these drives in more detail will appear in the May issue of *Product Engineering*. It will cover the variety of control and drive combinations for different horsepower ranges, several specific applications, and hints for designing these drives into original equipment.



Impact Extrusions

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Edgewater, N. J.

RECENT PROGRESS in the art of impact extrusion has kept pace with the demands of industry for stronger and lighter-weight parts in more varied and intricate shapes. New press equipment of increased capacity and improved design has extended the range of the process, both in the size of parts that can be produced and in the use of higher strength alloys.

Many of the desirable properties of aluminum impacts are directly attributable to the manner in which they are produced. When an aluminum slug held in a die is struck with a formed punch, the metal flows up through the annular opening between the punch and the die until the downward travel of the punch ceases. By properly controlling the cold flow, many desirable properties are developed in the metal of the part in a single stroke of the press. Articles produced in commercially pure 2S aluminum are work-hardened throughout. In highly stressed parts, produced in medium and high strength alloys, the mechanical properties are further enhanced by a grain structure that follows the general contours of the piece.

Of particular economic importance are such design features as thick closed-end sections combined with thin walls, solid bosses and tubular extensions on closed ends, and heavy flanges on tubular parts. These shapes are produced without draft, which saves weight and machining operations and also provides an accurate chucking surface for machining. Piece-to-piece dimensional variations during a production run are slight, and on certain designs it is possible to adhere to extremely close tolerances. For most commercial applications, the surface of the impact extrusion is smooth and bright and requires no grinding or finishing operations; and, being of wrought structure, parts take readily to decorative and protective coatings.

Minimum Wall Thickness

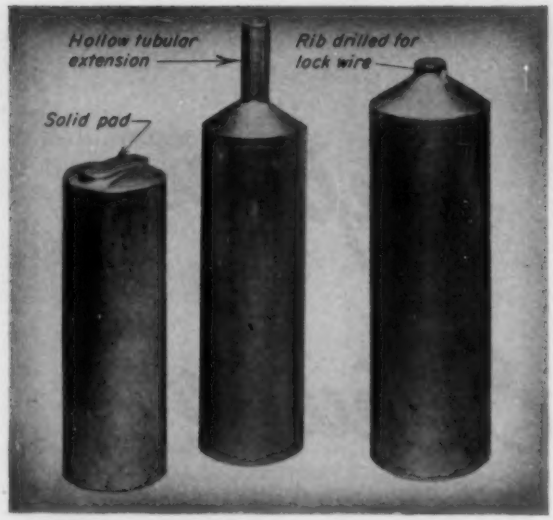
Dia of Shell, in.	Wall Thickness, in.	
	2S	A51S & 61S
3/4 & 1	0.010	0.040
1 1/2	0.015	0.040
2 & 2 1/2	0.020	0.060
3	0.025	0.080
3 1/2	0.025	0.090
4	0.030	0.100
4 1/2	0.040	0.125
5	0.060	0.156
6	0.075	0.156

Many of the wrought aluminum alloys can be impact extruded but for most requirements one of the following alloys, 2S, A51S, 61S or 14S will possess the required mechanical properties. In addition to aluminum, some of the magnesium and steel alloys are now being impact extruded.

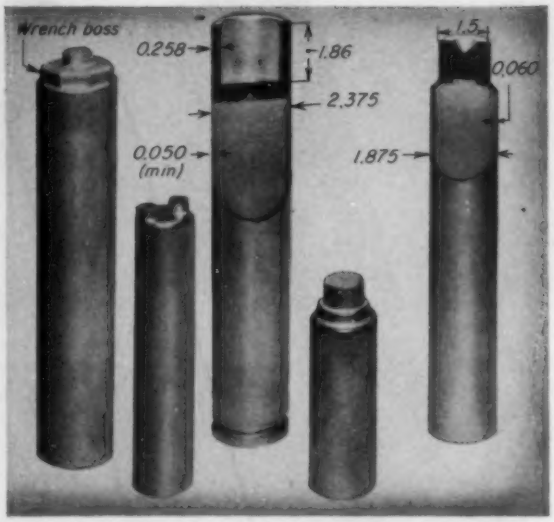
Commercially pure 2S in the work hardened condition and —F temper meets the strength requirements for many applications of extruded parts. Alloys A51S and 61S in the modified —T84 temper are used when additional strength is required. Higher strength requirements can be met with the 14S alloy heat treated to the —T6 temper. In general, this alloy is limited to the thicker sections and each application must be treated separately.

The studies on the next two pages show typical examples for different classes of impact extruded shapes. Taken as a group these parts demonstrate the wide range of shapes that can be produced by this versatile high-production process.

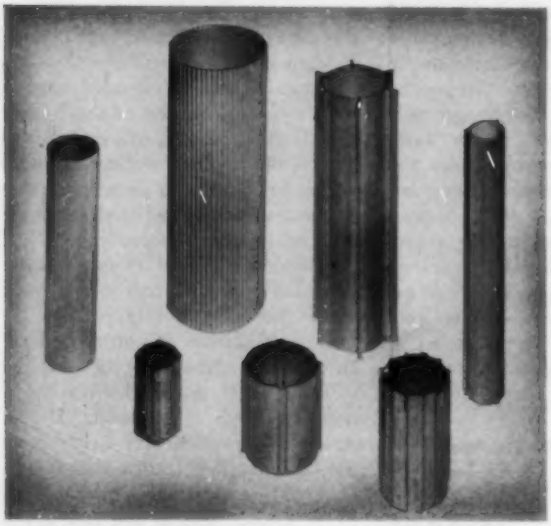
..... *Typical Examples of Impact Extrusions*



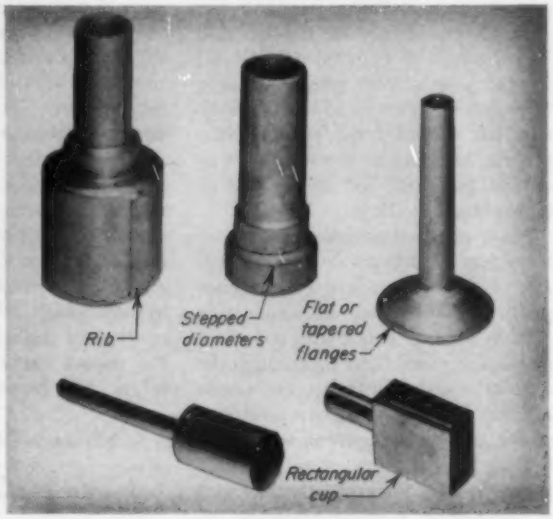
1 LARGE SIZE SHELLS. Larger impacts are generally produced in 2S aluminum with wall thickness ranging from 0.050 to 0.090 inch. The bosses, lugs and tubular extension on the closed ends provide means of attaching fittings and couplings. A flange can be formed on the base in a secondary operation. Approximate size limits with present equipment are 6 in. dia and 18 in. long. Among the many commercial applications for such shells are oil filters, reservoirs, sump tanks, and accumulators.



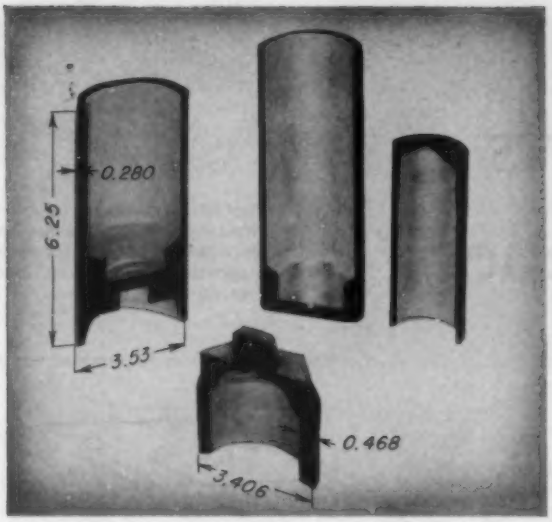
2 MEDIUM SIZE SHELLS. Fabricating and assembling problems are simplified by the use of impacts of relatively high length-to-diameter ratio. End fittings can often be eliminated by incorporating bosses and extensions of special shapes on the closed end. Strength requirements determine the choice of 2S or one of the stronger alloys. The sectioned shell on the left was reduced and beaded at the open end in secondary operations. Typical applications are pumps, cylinders, door checks, and air driers.



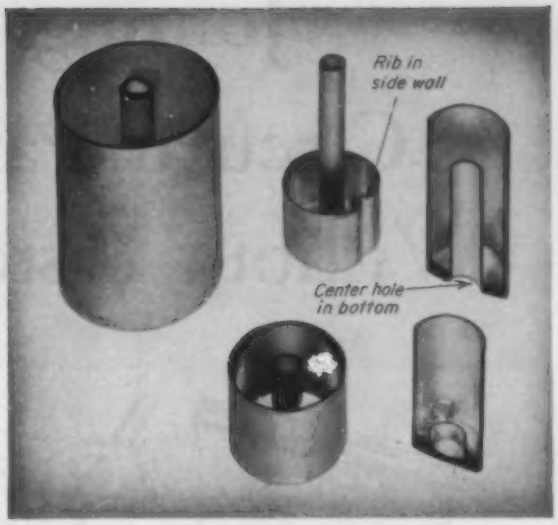
5 RIBBED PARTS. Some other variations of the cup shaped impacts are shells with ribs or fins on the outside surface. The ribs can be decorative, as in the two longer shells at left, or functional, as in the other parts. Similar ribs are also readily produced on the inside surface of shells. Parts with thin rib sections should be considered only in 2S aluminum; thicker sections, requiring additional strength, call for the stronger alloys. Shell at lower right forms cooling air channels in electric motor housing.



6 VARIATIONS OF TUBULAR PARTS. Combinations of cup shaped and tubular impacts, as well as flanged tubular parts are exemplified by these impacts. The flow of metal during forming of the two parts in the foreground and the part to the left at the rear is in both directions from the stepped section. Various auxiliary features, such as ribs, can be included in these designs, thereby reducing subsequent machining operations and attendant costs. All the parts shown are open through the center.

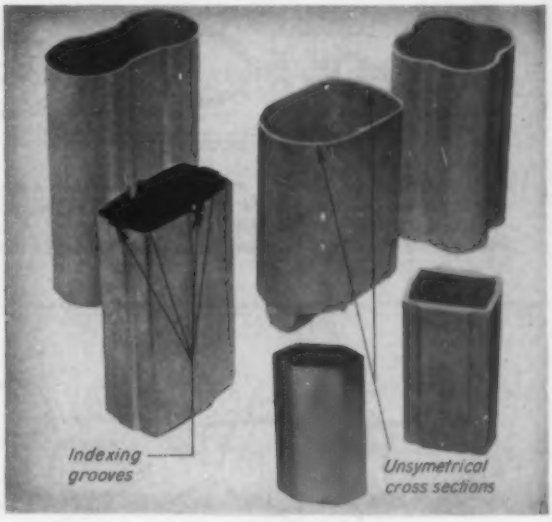


3 HIGH STRENGTH PARTS. The high strength characteristics of 14S-T6 alloy combined with the design possibilities of impacts are advantageous in critically stressed parts requiring machining operations such as threading and counter-boring. The shells illustrated are produced without draft to close dimensional tolerance, which simplifies chucking problems and minimizes machining. The three parts on the right are ammunition components; the part on the left is an accumulator cap.



4 INTEGRAL CENTER TUBE IMPACTS. These parts illustrate one of the many variations of the cup-shaped extruded shell. The inside center tubes are formed integral with the normal (outer) shell in one operation. They can be produced in round, oval or rectangular shapes in 2S aluminum or in the stronger heat-treatable alloys. The shell at left is an oil filter case and that at lower right a housing for a small electric motor. The other parts are Ordnance components which must meet rigid specifications.

7 SOLID IMPACTS. Slow, costly milling operations and prohibitive waste of stock are eliminated by the use of impact machining blanks shown above. They are produced in medium or high strength alloy, depending on design requirements. The outstanding advantages of impacts in this form are: Excellent machining properties of high strength alloys, draft free surfaces for chucking, close tolerances, efficient disposition of metal, and desirable grain structure for critically stressed parts.



8 SPECIAL SHAPE IMPACTS. Another advantage of the impact process is the resulting economical production of unusual cross-sectional shapes. The parts shown are typical of many functional shapes produced in one operation for various applications. Special design impacts (such as the two on the left) are used in the electronics industry for instrument cases, housings, shields and covers. High strength, thick-wall parts having angular shapes are sectioned axially and used as fittings to reinforce airframes.

Joining Circular Parts Without Fasteners

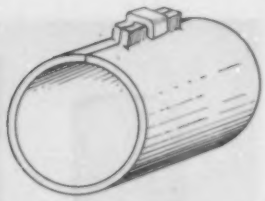


Fig. 1—Fastening for a rolled circular section. Tabs are integral with sheet; one tab being longer than the other, and bent over on assembly.

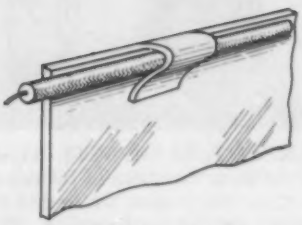


Fig. 5—Similar to Fig. 4 for supporting electrical wires. Tab is integral with plate and crimped over on assembly. Tab can be located as desired.

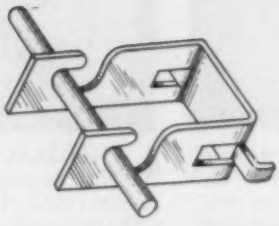


Fig. 6—For supporting of rods or tubes. Installation can be either permanent or temporary. Sheet metal bracket is held by bent tabs.

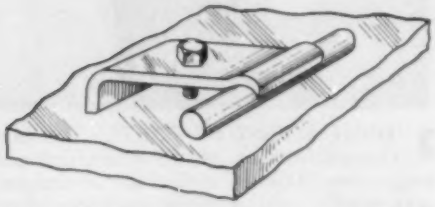


Fig. 7—Embossed sheet metal bracket to hold rods, tubes or cables. Tension is supplied by screw threaded into the lower plate.

Fig. 10—Plate is embossed and tabs bent over on assembly. If two plates are used having tab edges (B) a piano-type hinge is formed. (A) and (B) can be combined to form a quick release door mechanism. A cable is passed through the eye of the hinge bolt, and a handle attached to the cable.

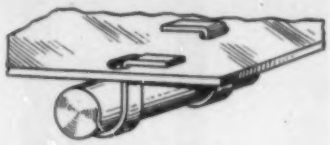


Fig. 11—Rods and tubes can be supported by sheet metal tabs. Tab is wrapped around circular section and bent through plate on assembly.

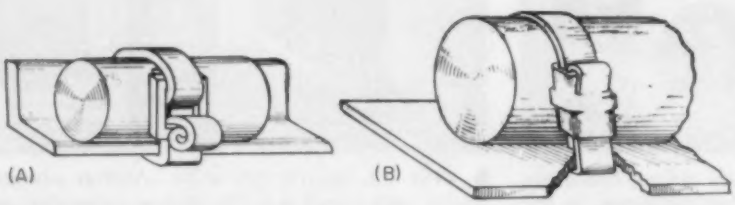


Fig. 14—Strap fastener to hold a circular section tight against a structural shape. Lock can be made from square bar stock (A) or from sheet metal (B) tabbed as shown. Strap is bent over for additional locking. Slotted holes in sheet should be spaced equal to rod diameter to prevent sheet tearing.

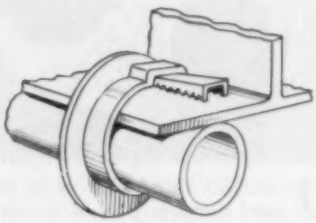


Fig. 15—*C* clamp support usually used for tubing. Serrated wedge is hammered tight; serrations keep wedge from unlocking.

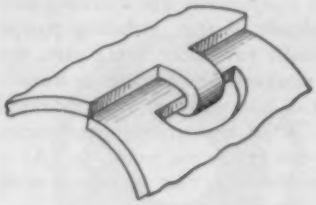


Fig. 2—Similar to Fig. 1 except tube is formed with a lap joint. Tab is bent over and inserted into cut-out on assembly. Joint tension is needed to maintain lock.

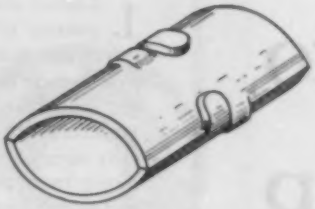


Fig. 3—Tab fastener for elliptical section. Tabs are formed integral with sheet. For best results tabs should be adjacent to each other as shown in sketch above.

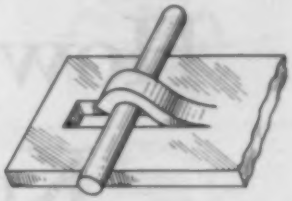


Fig. 4—For supporting rod on plate. Tab is formed and bent over rod on assembly. Wedging action holds rod in place. Rod is free to move back and forth unless restrained.

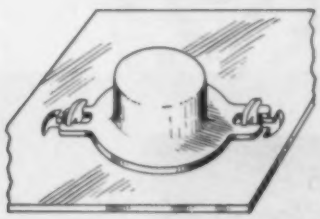


Fig. 8—Fastening of rod to plate. Rod is welded to plate with slotted holes. Tabs in bottom plate are bent on assembly.

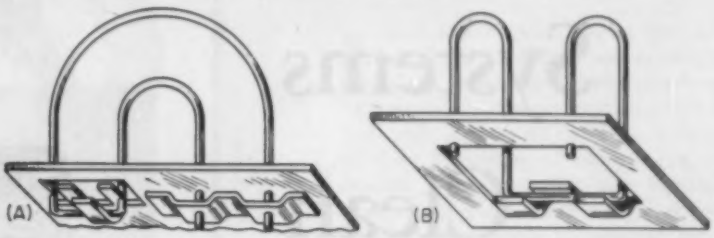


Fig. 9—Tabs and bracket (A) used to support rod at right angle to plate. Bracket can be welded to plate. (B) has rod slotted into place. For mass production, the tabs and slots can be stamped into the sheet. For limited production, the tabs and slots can be hand formed. The bracket can be stamped or hand formed.

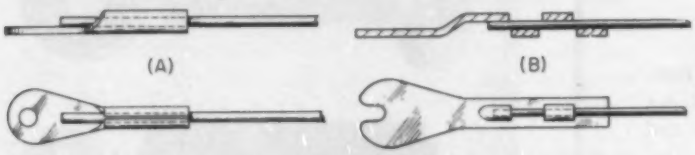


Fig. 12—For connecting wire ends to terminals. Sheet is crimped or tabbed to hold wire in place. Variety of terminal endings can be used. If additional fastening is required, in that parting of the wire and terminal end might create a safety or fire hazard, a drop of solder can be added on assembly.

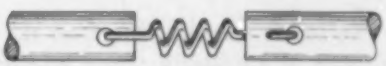


Fig. 13—Spring can be used to join two rods or tubes. Members are not limited in either axial motion or rotation except by strength of the spring.

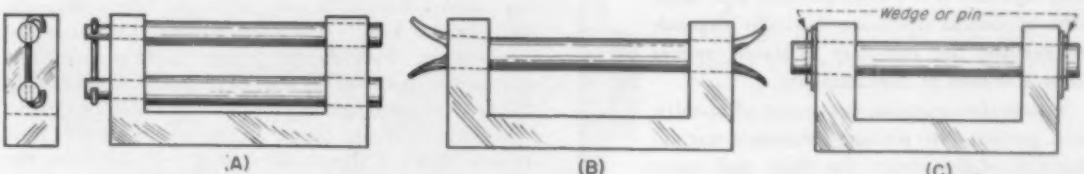


Fig. 16—Methods of locking rods in machine frames. In (A) one end of the rod is machined to a smaller diameter. Shoulder and bent member restrains rod from slipping out of frame. Limited axial and rotational freedom is present. Split rod in (B) limits axial motion but permits rotation. Rod is split on assembly. Wedge or pin in (C) bear against washers. Axial motion can be restricted but rotation is possible. If rod is to be a roller, bearings can be inserted in machine frame.

How to Keep Hydraulic Systems Clean

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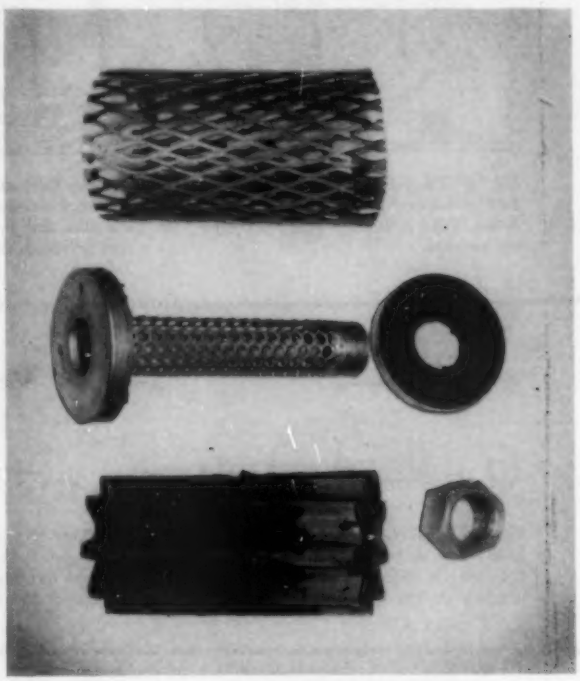
To obtain maximum life from the components of a hydraulic system involves not only the proper design of the system and selection of fluid cleaning elements, but also a rigorous maintenance schedule and the intelligent selection and care of the hydraulic fluid. The operating components of a system are well lubricated, usually protected from overload and can be stalled without damage. Since the hydraulic fluid serves the dual function of a power medium and lubricant, successful operation basically depends on keeping the complete hydraulic system clean and free of contaminants.

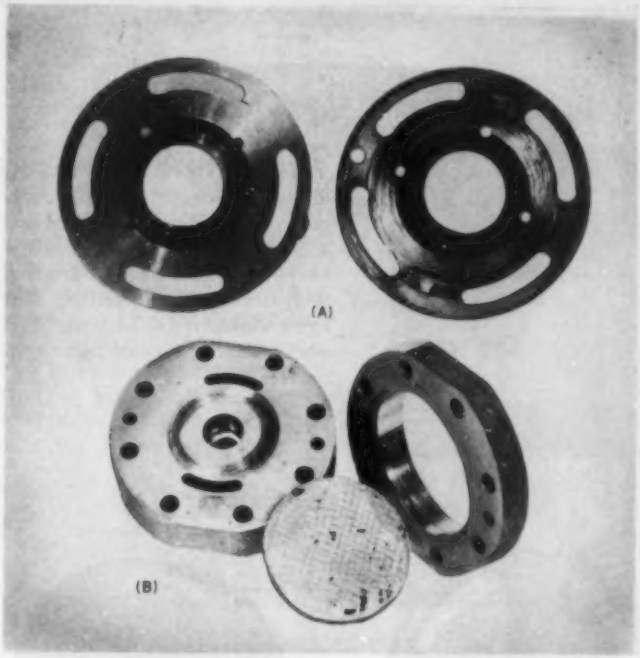
System contaminants can consist of metallic grit, particles of packing, moisture, carbon deposits, sludge from the fluid and many other similar items. The following material considers the various elements of a typical hydraulic system, with recommendations on service and maintenance procedures to keep the system clean and operating properly.

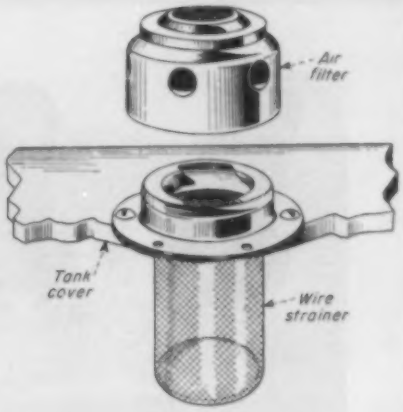
1. *Control and power components.* The operating components of a hydraulic system, including pumps, valves and motors, usually have close fitting parts that tend to wear in. The resultant wear particles or metallic grit must be removed or trapped to prevent additional (regenerative) wear. When regenerative wear occurs, early assembly and system failure can result. In (A) is shown two vane pump bushings that have been worn and scored from metallic grit.

Other system contaminants that usually come directly from the operating components are sand from castings, burrs from machining and fragments from damaged seals, packing and gaskets. (B) shows typical particles on a screen used for trapping this type of contaminant.



2. *Inlet filters and strainers at pump.* Filters, strainers, coolers, heaters and magnetic plugs are accessory components. They do not generate wear particles and are used to condition the fluid. Pump inlet filters usually have many small openings (about 0.005 in. dia) and are therefore easily clogged. The accompanying illustration shows a typical filter after removal from the system. A cleaning schedule of every three months is recommended for average usage. If the filters are not kept clean, the pump will be starved for oil (make noise like pumping rocks) and an early failure will result.



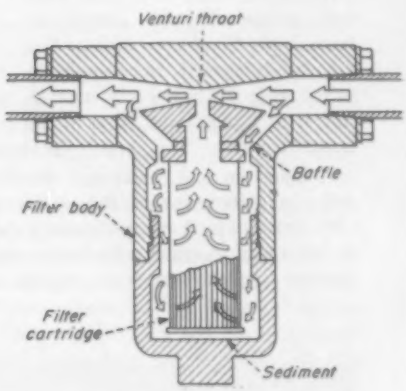


3. *Combination filler cap, strainer and air cleaner.* A strainer and air cleaner (breather) keep solid contaminants from entering the fluid reservoir during operation and during filling with hydraulic fluid. Breathers should be cleaned monthly. Frequently, oil bath type air cleaners are used where the air is unusually dirty. These require the same attention as the auto type air cleaner.

4. *Lines and fittings.* New lines and fittings must be properly cleaned and burred. If welded or brazed pipe or tube is used it should be pickled or neutralized with acid.

Hydraulic leaks must be repaired immediately. Pressure lines can be subjected to pressures below atmospheric at some points. This is caused by high velocity flows that introduce a venturi action. The wet condition of a hydraulic leak attracts solid particles and the venturi action pulls them into the hydraulic system. The valve in the figure shows an accumulation of particles caused by a wet condition of the external surface.

Leaks in the pump intake line will cause severe pump wear from cavitation as well as from contaminants that are drawn in.

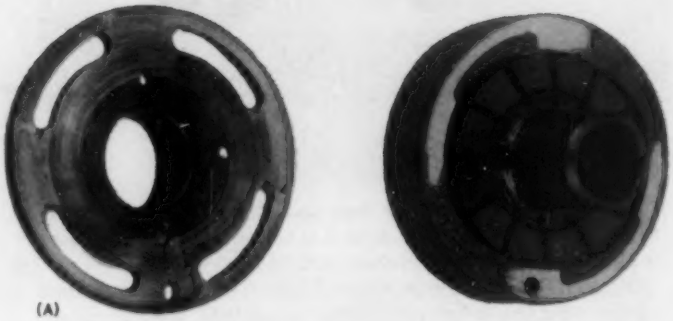


5. *Pressure and return line filters and strainers.* These are usually edge type filters or micronic type filters that strain or filter continuously. They must be cleaned or have cartridge replaced about every three months for best results. Sufficient clogging can result in a ruptured filter. If a proportional micronic type filter is used (see figure) less maintenance is required since only a part of the flow (proportional to flow) is filtered.

(continued on next page)

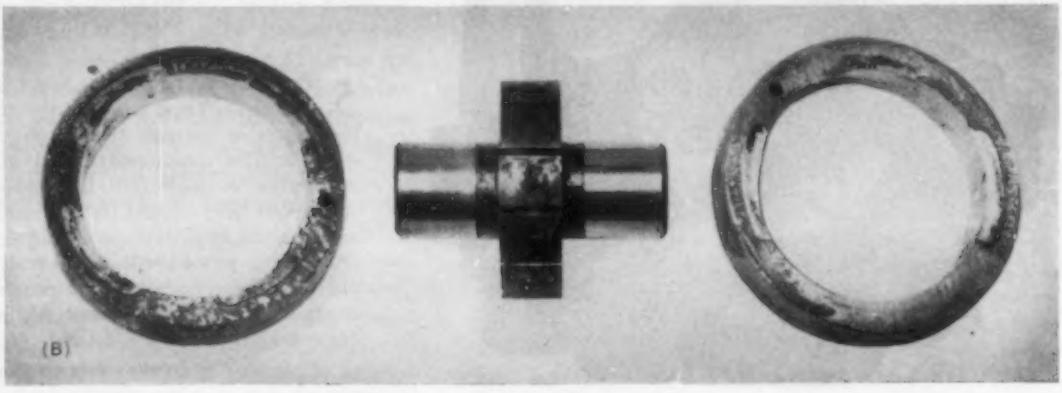
7. *Magnetic plugs.* Magnetic plugs can be used effectively to trap particles of magnetic materials. These plugs require removal and cleaning after the first three months of operation and about every six months thereafter. The figure shows typical magnetic plugs after several months of use.

6. *Heat exchangers.* These are used to heat or cool a hydraulic system for best performance. Heaters can scorch or char the hydraulic fluid and the resultant carbon and fluid breakdown can cause abnormal wear or malfunction of operating components. (A) shows pump cartridge elements with both wear and carbon deposits caused by burned oil. Conditions such as this can be prevented by completely submerging the heater and controlling with a thermostat close to the heater element. This avoids localized overheating.



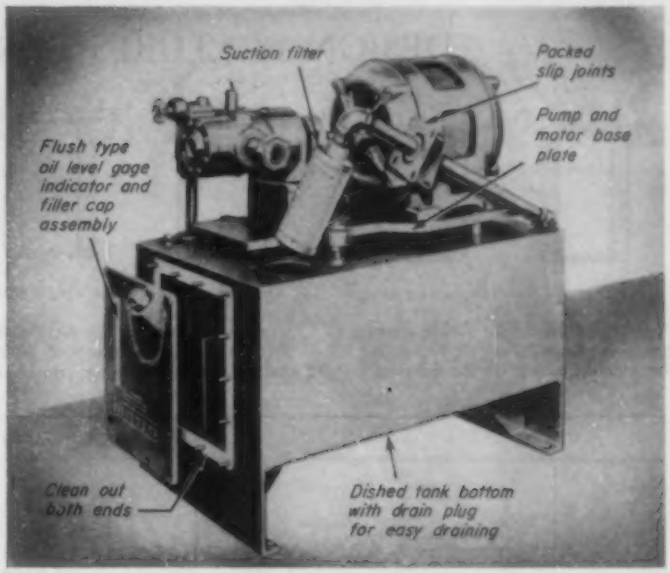
(A)

Coolers can leak water into the hydraulic system and cause corrosion of the operating components. (B) shows typical pump elements that were subject to entrained moisture. Hydraulic fluids should be checked frequently for water content and a low pressure relief valve used to protect the cooler from hydraulic pressure surges and subsequent internal failure and leakage. If cooling coils are used inside a reservoir, they must be completely submerged at all times to prevent sweating since this condition introduces undesirable moisture into the system.



(B)

8. *Reservoirs.* Properly designed reservoirs have baffles to trap contaminants and to prevent fluid agitation. They must also have adequate openings for proper cleaning. Reservoirs should be cleaned and refilled at least every six months. Paint condition inside the reservoir must be checked since peeling paint can clog filters, valves and other components. Paint also helps prevent internal rust and corrosion.


Suction filter
Packed slip joints
Pump and motor base plate
Flush type oil level gage indicator and filler cap assembly
Clean out both ends
Dished tank bottom with drain plug for easy draining

(A)

(B)

9. *Hydraulic fluids.* These should be selected in accordance with the specifications and recommendations of the component manufacturer and the fluid supplier. At least every three months the fluid should be checked to make sure it still meets the specifications. The important points are viscosity (shows sludging tendency), viscosity index (effected by contaminants and fluid breakdowns), and neutralization (acidity increases with fluid breakdown). The fluid should be replaced if these properties test outside of the specification limits.

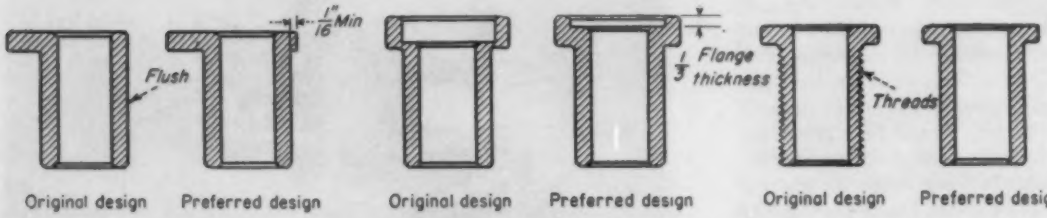
Sludge from fluid breakdown through overheating, contaminants or excessive component wear can cause sticking of the operating components. While a number of "de-sludging" agents are available, they should be used with care and never in large amounts since complete fluid breakdown can be caused by the excessive use of these agents. (A) shows a pump element almost completely clogged with sludge. Under normal operating conditions, sludging can be prevented by using a premium grade fluid and cleaning the system at regular intervals.

The use of a premium grade fluid will also prevent the formation of lint. Lint is an undesirable result of the manufacturing process of some hydraulic fluids and can stick valves and clog filters as shown by the lint filled filter in (B).

In some applications a portable filtering rig is used that continuously filters the system fluid while the equipment is operating. It can be taken from machine to machine and the filter element changed frequently without losing operating time.

A good general rule is to flush and refill the system after the initial breaking in period (24 to 48 hours).

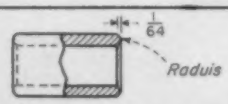
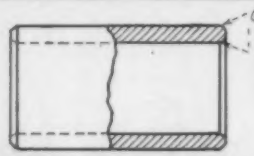
DESIGN FEATURES FOR SELF-LUBRICATING



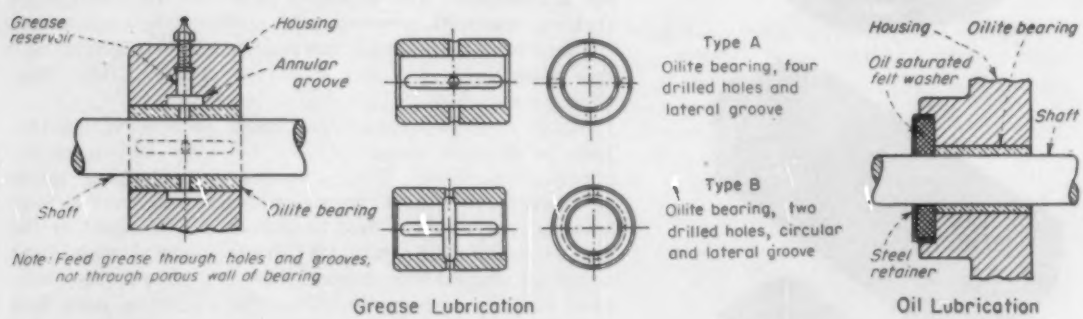
A 1/16 in. minimum flange overhang is desired to facilitate in the manufacturing of the bearing.

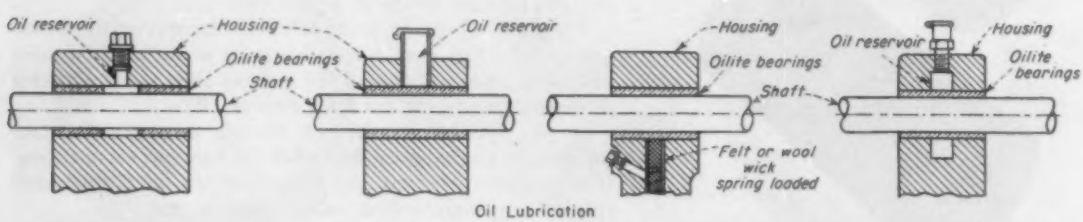
A deep counterbore should be made by machining. Counterbore should be limited to ⅓ flange thickness.

When threads are required, additional stock should be allowed on blank for machining the threads.

		Range	Chamfer size
Type A		All thin walls up to and including 3/32	Rounded end (1/64 "true radius")
Type B		On walls greater than 3/32 up to 3" O.D.	1/64 x 45°
		On all bearings 3" O.D. and over	1/32 x 45°

The O.D. chamfer on the lead end of the bearing acts as a pilot when bearing is inserted in housing. I.D. chamfer in the bearing serves as a lead when shaft is inserted. Bearing chamfers are indicated.





Various methods may be used in applications where external lubrication is desirable. The oil contacting the outside diameter of the bearing will be absorbed and filtered and cleaned of possible foreign particles before reaching the I.D. Such lubrication is desirable for vertical installations. Grease should be fed through holes and grooves and not through the porous walls of the bearing. These are recommended lubrication methods.

Powder Metal Bronze Bearings

Design data required to insure satisfactory service of self-lubricating bearings, including press fit values . . . dynamic load capacities . . . I.D. close-in . . . running clearances . . . methods of controlling I.D. . . . bearing chamfers . . . and design features.

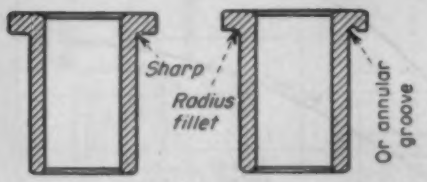
A. J. LANGHAMMER
President

PHILLIP GLICK
Staff Executive
Amplex Division, Chrysler Corporation

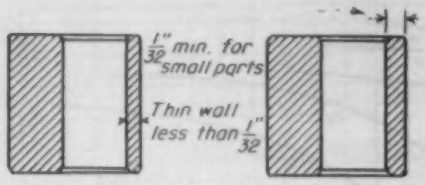
IN DETERMINING BEARING SIZE, it is necessary to consider the dimensions of related components, such as housing and shaft; and operating conditions, such as speed and load. In addition, when self-lubricating bronze bearings are being selected another factor is equally significant—the method used to install the bearing in its housing.

Bearings are usually installed in a chamfered housing by means of a shouldered arbor plug in an arbor press, Fig. 1, with a press fit whose value is indicated in Fig. 2. An

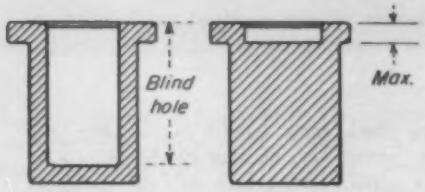
BRONZE BEARINGS



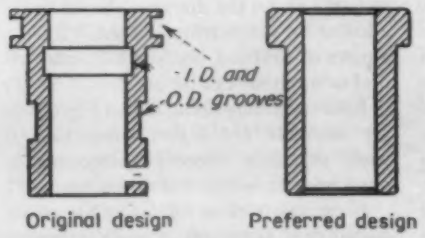
A rounded corner gives better powder flow in the die during manufacture of the bearing; increasing part strength and reducing stress concentration caused by a sharp corner.



1/32 in. minimum wall thickness is recommended for small parts. Wall should increase proportionately with part size. This is to assure good powder flow in the die cavity and to increase the life of the metal die.



Blind hole depth, when limited to flange thickness, increases strength of part. Deeper holes should be machined. Without the flange a blind hole can be manufactured.



Annular I.D. and O.D. grooves, and holes at right angles to direction of powder compression should be machined after sintering.

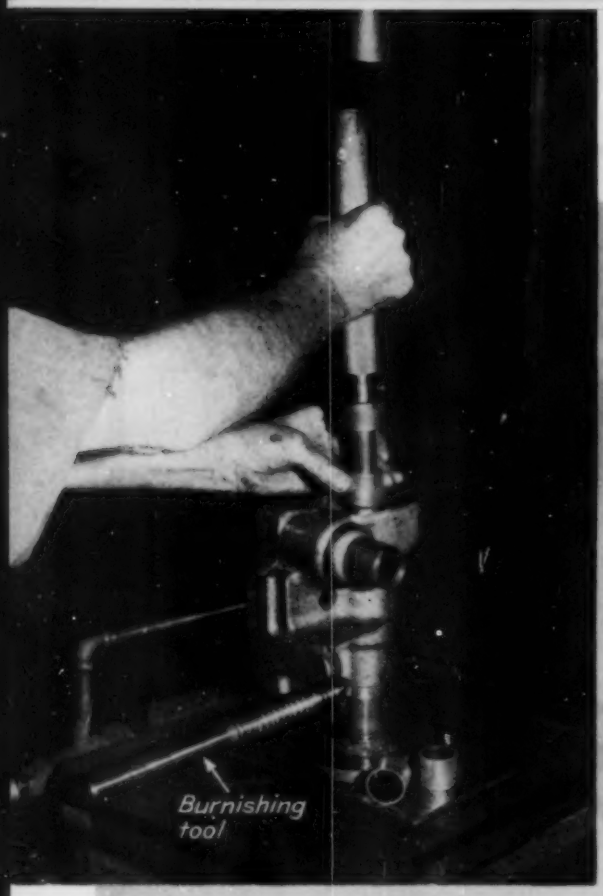


Fig. 1—Installation of a bearing in a steering gear housing by means of a shouldered arbor plug used in an arbor press. Note burnishing tool to be used to get desired running clearance on the bearing.

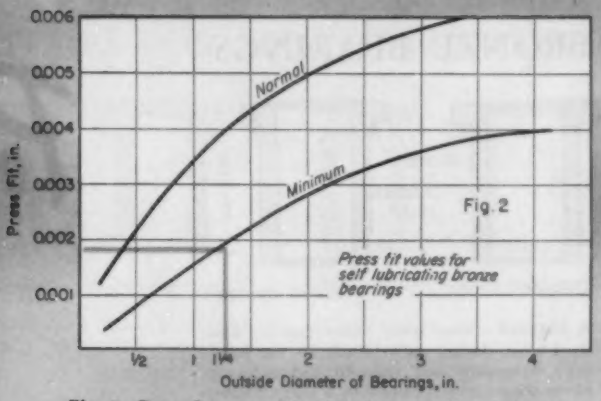


Fig. 2—Press fit values for self lubricating bronze bearings.

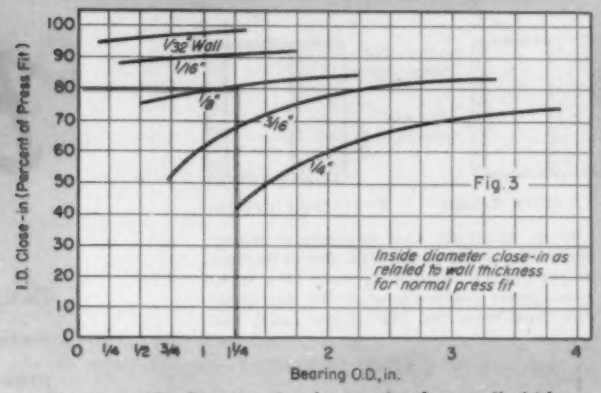


Fig. 3—Inside diameter close-in as related to wall thickness.

unchamfered edge on the housing bore might shear off metal from the bearing O.D. thereby seriously reducing the press fit. The fit causes a close-in of the inside diameter of the bearing, affecting the running clearance between bearing and shaft.

At least seven methods are available to assemble a bearing in a housing. These methods can be grouped, however, into three general classes: 1) a press fit where no tool contacts the inside diameter of the bearing and it is considered to be unrestrained; 2) a press fit where a combination insertion and sizing plug is used to restrain the bearing diameter from closing in; and 3) a press fit where the diameter is finished to size after installation by burnishing with a button burnisher, a piece of drill rod, steel ball or shaft, a roller type burnisher, or machining with a boring tool, or a reamer.

1. Unrestrained: If no tool contacts the I.D. of the bearing when it is inserted in the housing the press fit causes the bearing to close-in. The I.D. is reduced; the approximate amount of reduction varies with wall thickness and can be calculated from data like Fig. 3, and then checked by test samples. Regardless of the method used the unrestrained close-in value must be found.

2. Simple Sizing: The amount of close-in can be controlled by use of a combination insertion and sizing tool (Fig. 4). If this device is used, the plug diameter should be approximately 0.0003 in. greater than the final bearing I.D. Bearing selection is such that the plug fits freely in the bearing before installation. Then, when the bearing is pressed into the housing, its I.D. will close-in on the plug. Upon withdrawal the bearing I.D. will spring back about 0.0003 in., however, the exact amount must be determined by trial. Spring back data are empirical and can only be used as a guide.

3. Burnishing: For quantity production a button burnisher can be used (Fig. 5). The use of this tool allows I.D. tolerances to be controlled within 0.0005 in. Burnishing stock of 0.001 to 0.002 in. on the diameter should be allowed on the bearing. In small lots a piece of drill rod, shaft, a ball, mandrel or an arbor can be used.

Roller type burnishing tools (Fig. 6) are desirable for higher production work, especially where I.D. tolerance must be held within 0.0005 inches.

If extremely close tolerances are required or if alignment of holes in one or more bearings is necessary, boring can be resorted to with diamond or carbide tipped cutting tools. The tools must be dead sharp and operated at

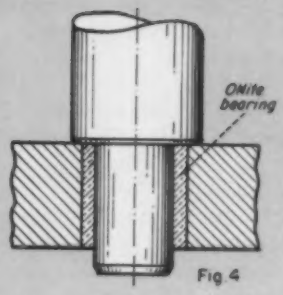
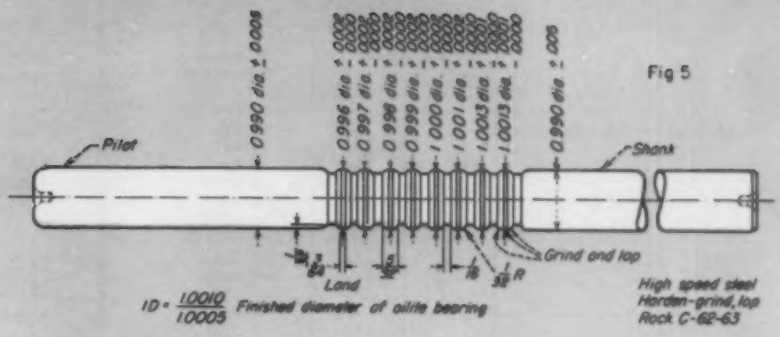


Fig 4



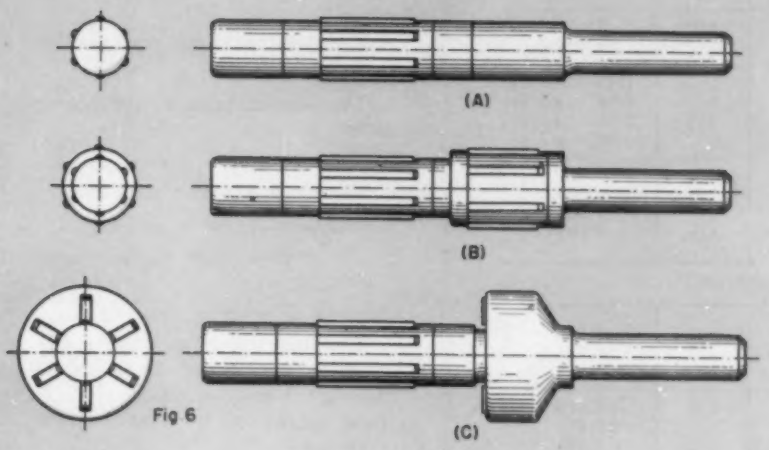


Fig 6

Fig. 4—Shouldered arbor for simultaneous installation and sizing. Bearing I.D. should permit free entry of the plug.

Fig. 5—Burnishing tool for quantity sizing of one or more bearings of identical diameters in the same housing. Tool used in arbor or power press.

Fig. 6—Roller type burnishing tools for quantity sizing of bearings of identical diameters. (A) is particularly effective for precision tolerances on small bores. (B) for finishing the I.D. of two different bearings in the same housing, and (C) for sizing of the I.D. and squaring the face of a flange bearing.

high speeds with a fine feed to preserve the original porosity of the bearing. Machining stock on the bearing diameters is held to a minimum, ranging from a few tenths of a thousandth to a few thousandths of an inch.

Reaming can be used but is not preferred because it is difficult to keep the cutting edges dead sharp, thus offering the possibility of smearing the bearing surfaces and closing the pores. If reaming is resorted to, tungsten-carbide tipped reamer edges should be used. Finishing stock should range between 0.001 and 0.003 inches.

Calculating Bronze Bearing Dimensions

If the housing bore and shaft diameter are known, a bronze bearing can be selected. But the method of installation, as described above, must be considered as it will affect the selection of the standard bearing size and the running clearance between bearing and shaft. The following examples illustrate the problem. Assuming that the:

Housing bore .....1.2495-1.2505 in.
Shaft diameter .....0.9995-1.0000 in.
Shaft material .....Cold rolled steel
Type of service.....Machine tool

1. Unrestrained I.D.

The initial step in any bronze bearing calculation, where data similar to the above are given, is to find the bearing O.D. The recommended minimum press fit values of Fig. 2 are added to the housing bore; or

1.2505 in. + 0.0020 in. = 1.2525 in.

This is the minimum bearing outside diameter. The maximum diameter is found by using Table I; or

1.2525 in. + 0.0010 in. tol. = 1.2535 in.

The actual maximum and minimum press fit values, bearing I.D. close-in values and running clearances can now be found by using the given limits as tolerances. For bearing O.D. and I.D. the upper limit is given first; while for housing bore, close-in and shaft diameter the lower limit is given first. This shows the extremes of the accumulated tolerances or the effect of stacking tolerances.

The maximum press fit occurs when the min. housing bore is subtracted

Table I—Standard Tolerance for Bronze Bearings[1]

PLAIN AND FLANGE BEARINGS

	Dimension		Standard Tolerances
	From	Up to	
Inside and Outside Diameters	...	½	0.001
	½	1	0.001
	1	1½	0.001
	1½	2½	0.0015
	2½	3½	0.002
	3½	4½	0.0025
Length	...	1½	±0.005
	1½	3	±0.0075
	3	4½	±0.010
Flange Diameter, Based on Flange OD:	...	1¼	±0.0025
	1¼	2½	±0.005
	2½	4	±0.010
Flange Thickness, Based on Flange OD:	...	1¼	±0.0025
	1¼	2½	±0.005
Flange Fillets and Radii, Based on Body OD:	...	1	1/32 ±0.010
	1	2	3/64 ±0.010
	2	2½	1/16 ±0.010
	2½	4	3/32 ±1/64
Concentricity, ID with respect to OD. (Maximum Total Indicator Reading) Based on ID:	...	1	0.003
	1	1½	0.003
	1½	3	0.004
	3	4½	0.005

THRUST BEARINGS

Inside Diameter	...	1¼	±0.005
	1¼	2½	±0.010
	2½	4	±0.015
Outside Diameter	...	1½	±0.010
	1½	3	±0.015
	3	4½	±0.020
Thickness	...	...	±0.0025
Parallelism of Faces, Based on OD:	...	1½	0.002
	1½	3½	0.003

[1]. All values in inches. Closer tolerances may be held when necessary.

from the max bearing O.D., or:

1.2535 in. — 1.2495 in. = 0.0040 in.

This is the actual press fit and would also be the close-in of the bearing I.D. except for the restraint offered by the wall thickness of the bearing. This restraint varies for various wall thickness and bearing O.D. as shown in Fig. 3. The close-in is, therefore, a percentage of the actual press fit and for a ⅛ in. wall and a 1¼ in. bearing O.D. is equal to 80 percent; or

0.0040 in. × 0.8 = 0.0030 in.

taken to the nearest 0.0005 in. This value is the maximum close-in value and gives the minimum clearance between the bearing I.D. and the maximum shaft diameter.

The minimum close-in value is found in a similar manner. Its value is:

0.0020 in. × 0.8 = 0.0015 in.

taken to the nearest 0.0005 in.

Using the maximum close-in value, the minimum running clearance value from Fig. 7 and the upper limit of the shaft diameter the smallest bearing I.D. is:

0.0030 in. + 0.0005 in. + 1.0000 in. = 1.0035 in.

The maximum bearing I.D. using the tolerance value from Table I is:

1.0035 in. + 0.0010 in. = 1.0045 in.

Bearing length is usually considered to be equal to approximately 1½ times shaft diameter; or

1½ × 1.0000 in. = 1½ in.

From the above information, a computed bearing of the following dimensions is needed:

1.0045/1.0035 I.D.
× 1.2535/1.2525 O.D. × 1½ Lg.

The closest standard Oilite bronze bearing is:

1.006/1.005 I.D.
× 1.254/1.253 O.D. × 1½ ± 0.005 Lg.

A calculation must be made to check the running clearance based on the new values of bearing I.D. and O.D. The clearance must be greater than the minimum value or a bearing failure can occur.

The actual maximum press fit is:

1.2540 in. — 1.2495 in. = 0.0045 in.

The close-in value to the nearest 0.0005 in. is:

0.0045 in. × 0.8 = 0.0035 in. max.

The actual minimum press fit is:

1.253 in. — 1.2505 in. = 0.0025 in.

The close-in value to the nearest 0.0005 in. is:

0.0025 in. × 0.8 = 0.0020 in. min.

The final maximum bearing I.D. is the subtraction of the maximum bearing I.D. and the minimum close-in value caused by the new press fit value; or

1.0060 in. — 0.0020 in. = 1.0040 in.

The maximum running clearance is found by using the minimum shaft diameter:

1.0040 in. — 0.9995 in. = 0.0045 in.

The final minimum close-in bearing I.D. is:

1.0050 in. — 0.0035 in. = 1.0015 in.

The minimum running clearance is:

1.0015 in. — 1.0000 in. = 0.0015 in.

The running clearances are above the minimum chart value and an average value of 0.003 in. is found. This is also above the mean recommended value, Fig. 7, of 0.0014 inch.

2. Restrained I.D.

For a narrower range of running clearance limits, a bearing can be selected with an I.D. about 0.0015 in. smaller than the computed value to provide sizing stock. The new I.D. is:

1.0045/1.0035 — 0.0015 in.
= 1.003/1.002 in.

The closest standard Oilite bearing is:

1.003/1.002 I.D.
× 1.253/1.252 O.D. × 1½ ± 0.005 Lg.

The maximum actual press fit value for the new bearing O.D. is:

1.2530 − 1.2495 = 0.0035 in.

The min actual press fit value is:

1.2520 − 1.2505 = 0.0015 in.

The average value is 0.0025 in. which is above the recommended minimum value from Fig. 2 of 0.0020 in.

The close-in factor from Fig. 3 remains constant at 80 percent of the press fit. The close-in value to the nearest 0.0005 in. is:

0.0035 in. × 0.8 = 0.0030 in. max.

and

0.0015 × 0.8 = 0.0010 in. min.

The maximum running clearance can now be calculated for the bearing I.D. of 1.003 in. The close-in for maximum clearance is 0.0010 in. to give an unrestrained inside diameter of

1.003 in. − 0.0010 in. = 1.0020 in.

The minimum shaft diameter is 0.9995 in., thus the maximum running clearance is:

1.0020 in. − 0.9995 in. = 0.0025 in.

However, the minimum unrestrained diameter is:

1.0020 − 0.0030 = 0.9990 in.

But, the diameter is being restrained by a plug, similar to that shown in Fig. 4. Assuming a plug diameter of 1.0013 in. The smallest inside diameter, upon removal of the plug, is equal to 1.0010 in. This takes into consideration the natural spring-back value of 0.0003 in.

The maximum shaft diameter is 1.0000 in., thus the minimum running clearance is:

1.0010 − 1.0000 = 0.0010 in.

The average running clearance is approximately 0.0015 in. which is close to the mean value from Fig. 7 of 0.0014 in., and all values are above the minimum value of 0.0005 inches.

3. Sizing I.D. with Burnisher

For still closer control of the I.D. tolerance, a sizing tool, such as a button burnisher, can be used in conjunction with a bearing of smaller I.D. than above. A bearing must be selected that provides for burnishing stock on both the high and low limits. The closest standard Oilite bearing is:

1.001/1.000 I.D. × 1.253/1.252 O.D.
× 1½ ± 0.005 Lg.

When inserted in the housing the bearing I.D. will close-in by the same amount as above since the outside diameters of the bearings are the same. The unrestrained I.D. will become:

1.0010 in. − 0.0010 in. = 1.0000 in. max.
1.0000 in. − 0.0030 in. = 0.9970 in. min.

The running clearances between shaft and bearing are:

1.0000 in. − 0.9995 in. = 0.0005 max.
0.9970 in. − 1.0000 in. = NO GO

Therefore, the unrestrained diameter must be burnished to allow for the minimum running clearance. The minimum bearing inside diameter must be larger than the shaft by the minimum running clearance or

1.0000 + 0.0005 = 1.0005 in. min.

The maximum bearing inside diameter can be maintained at 1.0010 in. The burnished bearing I.D. is then 1.0010/1.0005 in. and the burnishing tool shown in Fig. 5 is used. The amount of burnishing stock is:

1.0010 in. − 0.9970 in. = 0.0040 in. max.
1.0005 in. − 1.0000 in. = 0.0005 in. min.

The average burnishing stock on the diameter is approximately 0.0020 in. or approximately 0.0010 in. per side.

The running clearances between bearing and shaft are:

1.0010 in. − 0.9995 in. = 0.0015 in. max.
1.0005 in. − 1.0000 in. = 0.0005 in. min.

The average running clearance is 0.0010 in. All values are above the minimum recommended value.

Fig. 7—Mean and minimum clearances for bronze bearings related to shaft diameter.

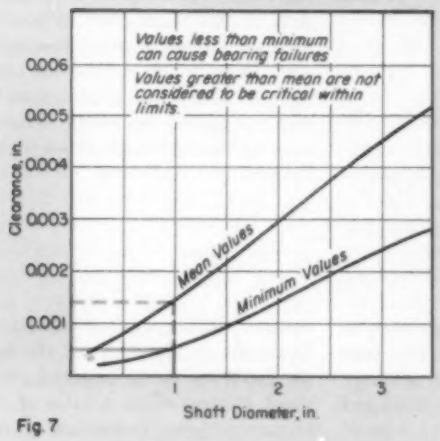


Fig. 7

Fig. 8—Dynamic load capacities at speed for bronze bearings based on a *PV* value of 50,000.

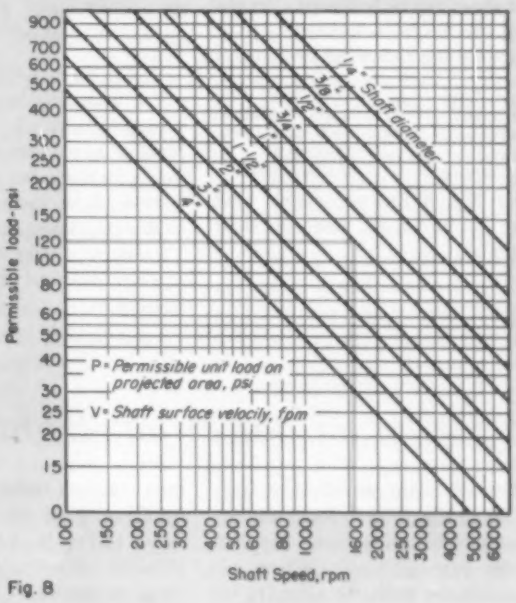
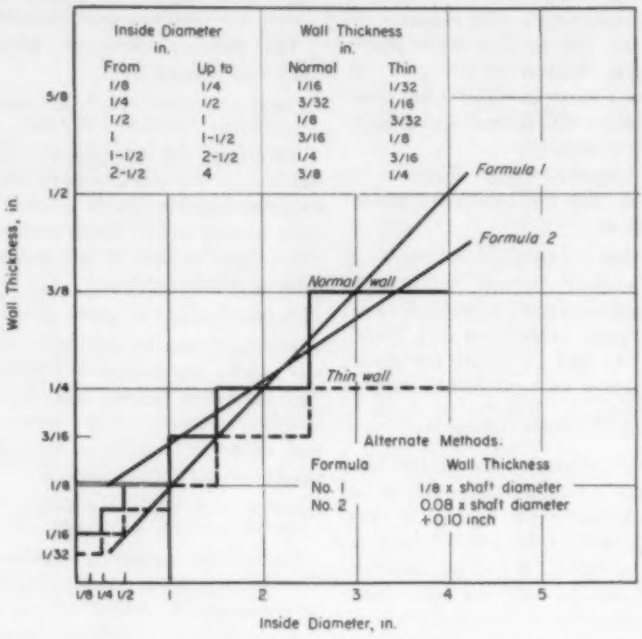


Fig. 8



Experience usually dictates the wall thickness best suited to a particular application. Therefore, the 3 methods shown in this chart are meant to serve only as a guide.

A quick rule of thumb for getting wall thickness is shown by Formula No. 1. Formula No. 2, however, is preferred by some designers. The tabulation represents old standby handbook values.

Factors favoring the use of thicker wall bearings than shown by this chart are:

1. Need for increased self-contained oil reservoir capacity, especially when an external reservoir is not possible because of space limitations. (Heavy walls are permitted in the absence of excessive pressures.)

2. Need for increased stiffness while bearings are being pressed in when they are somewhat longer than normal.

3. Replacement of ball bearings by sleeve bearings.

Other conditions might make a thinner wall desirable:

1. To gain additional backing support from the housing for heavy loads.

2. To minimize restrictions imposed by housing design, cost, etc.

Fig. 9—Three methods of determining wall thickness for bronze bearings.

Calculating Bearing Size and Housing Bore

When operating conditions are known, such as load and speed, the bearing size as well as the housing bore can be calculated. If closer running tolerances are desired the procedure described above can be followed after the bearing size has been selected.

Assuming the following given data:

Maximum Load ..... 150 lb total
Shaft diameter ..... 0.9995-1.0000 in.
Shaft material ..... Cold rolled steel
Shaft speed ..... 1,600 rpm
Type of service ..... Machine tool

From Fig. 8 the permissible unit loading can be found, based on shaft diameter and speed.

$$\text{Load} = 120 \text{ psi}$$

Required bearing area equals:
150 lb/120 psi = 1.25 sq in.

Since shaft is 1.0000 in. dia, required bearing length equals:

$$L = 1\tfrac{1}{4} \text{ in.}$$

However, bearing practice usually considers bearing length to be equal to approximately $1\frac{1}{2}$ times shaft diameter; Therefore,

$$L = 1\tfrac{1}{2} \times 1.0000 \text{ in.} = 1\tfrac{1}{2} \text{ in.}$$

For a bearing length of $1\frac{1}{2}$ in., the projected area = $1\frac{1}{2}$ sq in., which gives an actual unit loading of 100 psi, thus providing for a safety of factor.

Now, from formula 1 of Fig. 9
Wall thickness equals:
$\frac{1}{8}$ x shaft diameter = $\frac{1}{8}$ in.

Thus, nominal dimensions for the bearing are:

1 in. I.D. × $1\frac{1}{4}$ in. O.D. × $1\frac{1}{2}$ in. long.

Select Standard Oilite:

1.003/1.002 I.D. × 1.253/1.252 O.D. × $1\frac{1}{2} \pm 0.005$ Lg.

If a housing bore of 1.2495/1.2505 in. is selected, an average press fit value of 0.0025 in. between bearing and housing is obtained. This value is safely above the chart minimum value, Fig. 2, of 0.0018 inches.

Had the loading been higher, a proportionately longer bearing would have been selected; if lower, a proportionately shorter bearing would have been used so as to affect saving in space and cost. Oilite bearings have successfully replaced heavy-duty solid bronze bearings when the operating conditions were substantially higher than the chart value of PV = 50,000.

Factor of Safety for Bronze Bearings

A limited factor of safety is provided for in Fig. 8. It is based on normal usage, lubrication being supplied from the bearing, itself. Where adverse conditions exist, the safety factor should be increased. It is not uncommon for such factors to be as high as 4, using $\frac{1}{4}$ of the permissible load values in Fig. 8. An example is an application subject to frequent starts and stops, or one where the shaft has oscillatory motion. Of importance, in this instance, is the magnitude of the oscillation, the smaller its value, the higher the factor of safety required. Where shock loading exists, a value of 2 can be used; higher factors are used for more severe cases. For unit loadings

over 6,000 psi, an extreme pressure, (EP), lubricant should be used.

Other items that make it necessary to provide an additional factor of safety are:

1. Misalignment. Imposes unequal loading on bearing surface setting up excessively high stresses in localized areas.

2. Weak shaft, allowing flexing under load. Imposes unequal loading on bearing surface setting up excessively high stresses in localized areas.

3. Poor shaft finish. Results in excessive wear on inside diameter of the bearing.

4. Incorrect bearing clearance. Insufficient clearance can cause seizing; excessive clearance reduces effective bearing area. Increasing the clearance slightly above the mean value increases the allowable PV value.

5. Presence of dust, grit, moisture, injurious fumes. These have destructive effect on the working surface of the bearing and shaft.

6. Extremely low or high temperature. Reduces the physical properties of the metals.

PV values can be used that exceed chart allowances when subsequent lubrication is provided, as from a reservoir or oil sump; when the bearings are immersed in oil, as in a transmission; when the service is of short duration, as in an engine starter; when provision is made for cooling the bearing; and when the shaft is hardened and ground or chrome plated.

If grease must be used provision should be made for lubricating the shaft directly through holes drilled in the bearing wall.

An insufficient factor of safety may result in the costly downtime of expensive machinery and the critical tie-up of important operations. A generous factor of safety should be provided where continuing operation is mandatory, as in aircraft service, marine operation and others.

NEW PROCESS MAKES ULTRA-PURE METALS

REFINING A SUBSTANCE to a point where only one atom of impurity exists in ten billion atoms of the material is the result of a new process developed by engineers at the Bell Telephone Laboratories. Called zone-melting, the new process is already in use in the purification of germanium for transistors, whose operation depends on obtaining germanium in a highly purified form. The electrical properties can then be altered to the desired amount by the controlled addition of such impurities as phosphorous, arsenic and antimony.

Not limited to germanium alone, the new process is also being used to refine a variety of metals, semiconductors such as silicon and the compound indium-antimonide, and organic and inorganic substances. Extremely pure tin and antimony, for example, have been made, and metallurgists at Bell believe many other ultra-pure metallic materials should be available soon.

The zone-melting process is based on the fact that the impurities are not equally soluble in the solid and liquid states of a substance. Usually, the impurities are more soluble in the liquid. Taking advantage of this, a narrow molten zone is moved slowly along an ingot of relatively impure material and draws the impurities to one end of the ingot.

This is done by passing the ingot through a circular induction heater which, as in the case of germanium, brings it to a molten state at a temperature of about 1,760 F. As the ingot is passed through the heater, the molten zone holds the impurities, while the ingot solidifies into a purer state on the other side of the heater.

A series of these circular heaters is used in actual practice, and each molten zone extracts its share of impurities from that left by the preceding zone. Then, at the end of the run, the impurities have been "swept" to one end of the ingot, where they are trapped when the tip of the ingot passes out of the heater and solidifies. This section may then be cut off.

The extent of purification that is attained depends on four things: the number of passes made; the initial impurity level; the difference in the solubility of impurities in the solid and liquid; and on how short the zone may be made. Impurities which raise the melting point can be removed by zone-melting also, but the mechanism required is most complicated. In this case impurities travel in a direction opposite to that of the zone and, in general, more passes are needed.

It is not necessary to make a number of separate passes. If the induction heaters are aligned in series and the ingot run through them in one pass, considerable time is saved.

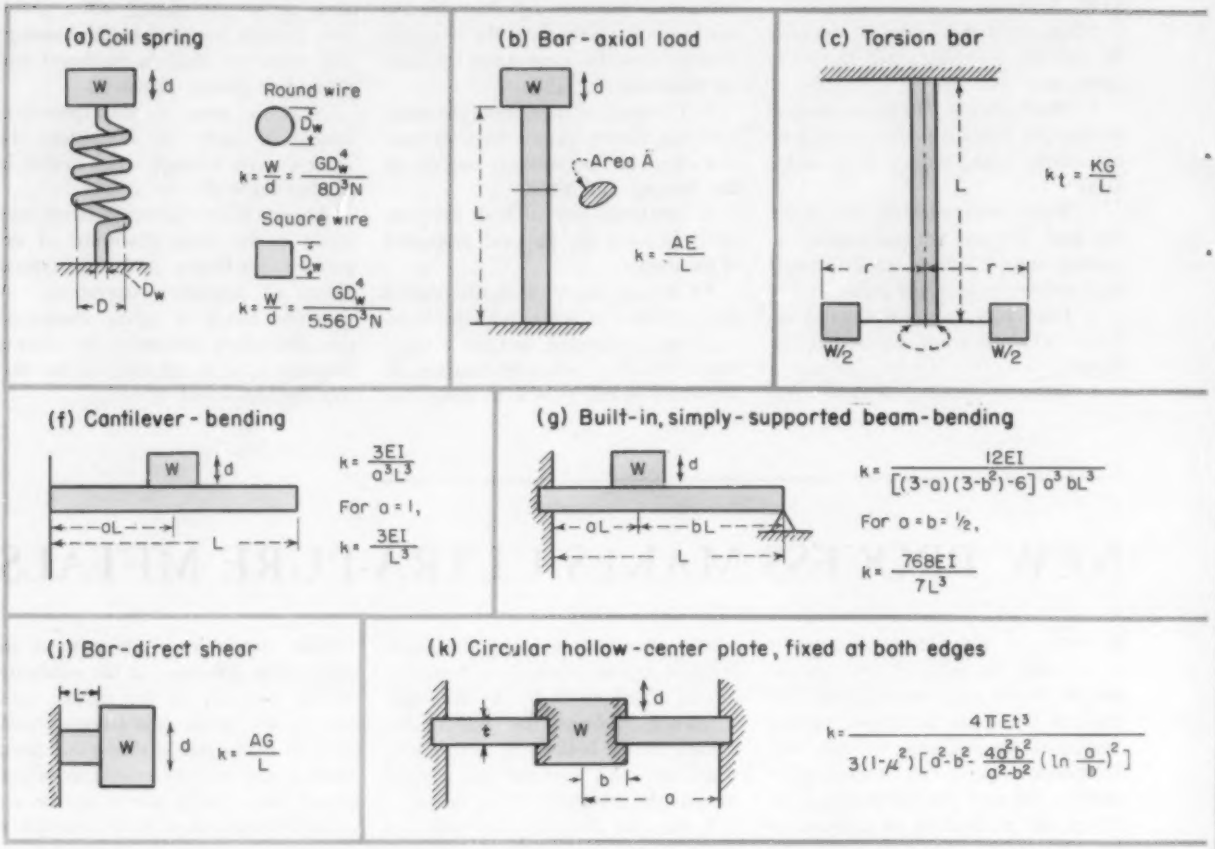
Bell Lab. engineers say that the new process can be applied to any solute-solvent system in which there is an appreciable difference in the solubility of the impurity in the molten substances, and in the solid freezing from it. The mathematical theory has been worked out, and the results to be expected for a given system can be accurately predicted if these solubilities are known.

The sweeping action of the zone-melting process serves two purposes. Besides getting the utmost in purification, the process also permits the identification of impurities which may be present in such small amounts that they do not permit positive detection by any of the available analytical devices. However, once the impurities are concentrated at one end of the ingot they are more easily identified.

As an example of one application of this process, a type of copper from Chile has in it an unknown material that makes it particularly adaptable to copper oxide rectifier use. The amount of this material is so small that it cannot be detected by the mass spectrograph. Zone-melting, therefore, offers the possibility of concentrating the impurity to a quantity to permit identification, and of making an ultra-pure copper as a starting material.

Besides its use in manufacturing applications, the process is being used as a research tool for laboratory investigations of the effects of impurities on various materials.

Table I—Stiffnesses of Typical Structural Elements



Calculating Fundamental of Machines on

WALTER W. SOROKA
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FOR AN UNDAMPED translation system, the simplest method for obtaining the fundamental natural frequency of a machine on a flexible support is by means of the formula:

$$f_o = \frac{1}{2\pi}\sqrt{\frac{kg}{W}} \qquad (1)$$

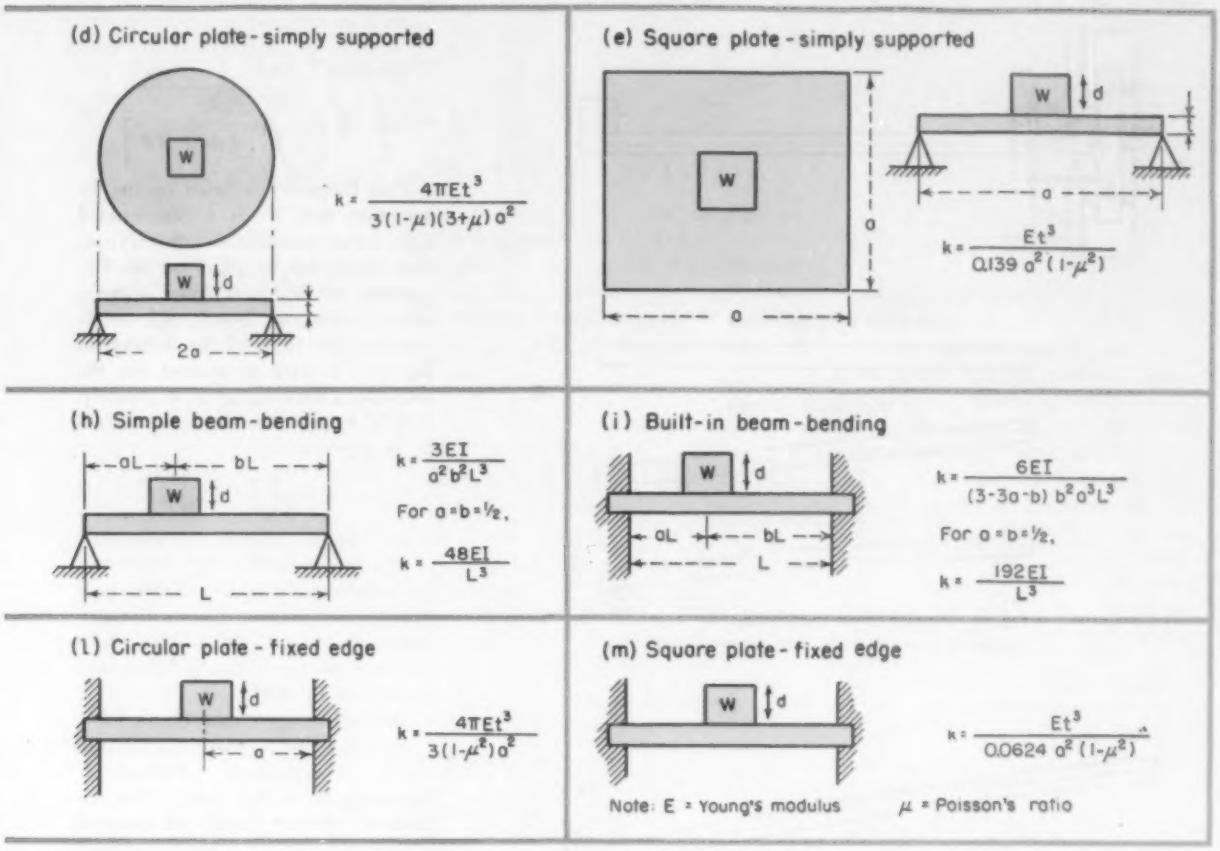
For natural oscillations of a torsional system, the frequency is:

$$f_t = \frac{1}{2\pi}\sqrt{\frac{k_t g}{W\rho^2}} \qquad (2)$$

For machines mounted on various typical structural elements the values of k (or k_t) may be obtained directly from load-deflection data in handbooks. Such values are shown in Table I for shafts, beams, plates and other common elements.

In each case in Table I the flexible structural element rests on rigid supports. However, in practical applications these supports almost invariably deflect under load, in translation and/or rotation. To ignore this phase of an isolation problem can, in a great many applications, be of such significance as to render an otherwise satisfactory solution completely useless.

One method of accounting for support yield, including the effect of weight of structure on the transmission of vibratory forces to the support is by superposition of deflection formulas. This will be illustrated for beam-type structures in the following paragraphs.



Frequencies Flexible Structures

Flexibly-Supported Cantilever

Referring to sketch (f) in Table I, the "fixed" support may be represented schematically as shown in Fig. 1(A). The torsional stiffness of the support is simulated by two springs, each of stiffness k_o, spaced a distance $2e$ apart. Thus, the torsional stiffness k_t is $2k_oe^2$ in. lb/radian. The translational stiffness is k_1. Both k_t and k_1 can be determined analytically or experimentally in a load-deflection test.

Knowing k_t and k_1, the value of k for use in Eq (1) can be obtained by superposition of the three deflections shown in Fig. 1(B), (C) and (D).

The principle of superposition is based on small deflections; that is, the geometry of the structure is not ap-

NOMENCLATURE

Symbol	Definition
k	Support stiffness, lb/in.
k_t	Torsional stiffness, in.-lb/radian
W	Oscillating weight, lb
g	Acceleration of gravity (386 in./sec²)
f_t	Torsional natural frequency
f	Frequency of applied force
τ	Transmissibility or ratio of transmitted to applied force
f_o	Natural frequency
d	Static deflection, W/k
ρ	Radius of gyration, in.
w	Weight per unit length, lb/in.

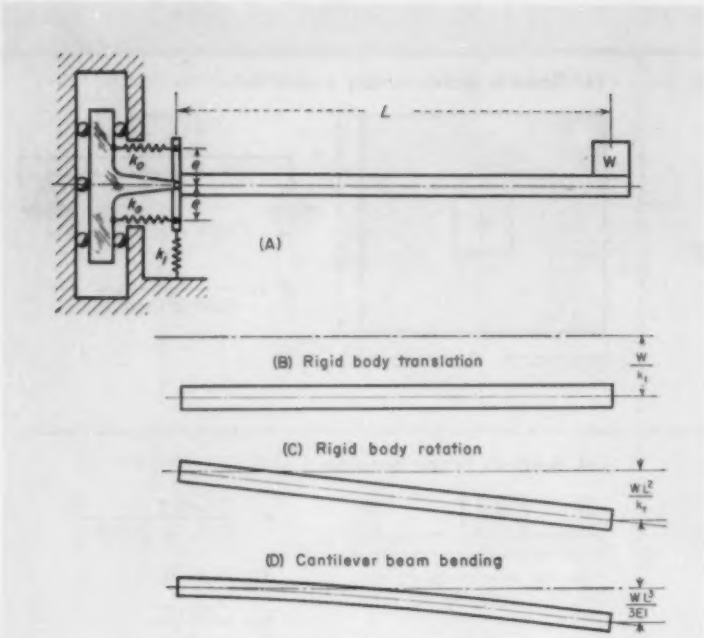


Fig. 1—Displacement components of cantilever beam with flexible support.

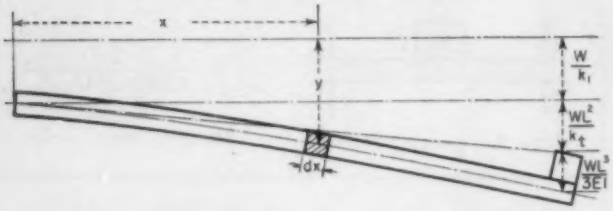


Fig. 2—Coordinates for Rayleigh Analysis of beam vibration.

precisely affected by the deflections. On this basis the total deflection of the load W is:

$$d = \frac{W}{k_1} + \frac{WL^2}{k_t} + \frac{WL^3}{3EI} \qquad (3)$$

The stiffness is:

$$k = \frac{W}{d} = \frac{1}{\frac{1}{k_1} + \frac{L^2}{k_t} + \frac{L^3}{3EI}}, \qquad (4)$$

and the natural frequency of W on the flexibily-supported elastic beam is:

$$f_o = \frac{1}{2\pi}\sqrt{\frac{g}{W\left(\frac{1}{k_1} + \frac{L^2}{k_t} + \frac{L^3}{3EI}\right)}} \qquad (5)$$

The frequency given by Eq. (5) does not include the effect of the distributed weight of the beam. This can be included, when necessary, with adequate accuracy by the Rayleigh method. With this method, the kinetic energy of the vibrating system, as it goes through its equilibrium position, is equated to the strain energy in the system at the extreme displacement of the beam. Fig. 2 shows the beam at an extreme position under the three deflections given in Fig. 1. The deflection y at any distance x from the supported end is given by:

$$y = W\left(\frac{1}{k_1} + \frac{Lx}{k_t} + \frac{3Lx^2 - x^3}{6EI}\right) \qquad (6)$$

The kinetic energy of the vibrating system is:

$$T = \frac{2\pi^2 f_o^2}{g}\left[w\int_0^L y^2\,dx + Wd^2\right] \qquad (7)$$

The expression y^2dx involves only powers of x, so that the integration called for by Eq (7) is straightforward, if somewhat cumbersome.

The strain energy in the beam due to the load W is found from:

$$U = \tfrac{1}{2}Wd$$

Then, since $T = U$,

$$f_o = \frac{1}{2\pi}\sqrt{\frac{Wdg}{\left[w\int_0^L y^2\,dx + Wd^2\right]}} \qquad (8)$$

This frequency is based on the assumption that W is a concentrated load (zero moment of inertia), so that tilting has no effect on the frequency. If W does have appreciable moment of inertia, I_w, its effect can be included by adding to Eq. (7) a term to account for the rotational kinetic energy of W, namely, $2\pi^2 f_o^2 I_w \theta_d^2/g$. The tilt θ_d in radians is, by superposition:

$$\theta_d = WL\left(\frac{1}{k_t} + \frac{L}{2EI}\right) \qquad (9)$$

In a similar fashion, the rotational energy of the beam cross sections can be included. The rotational effects are usually small in comparison with translation effects for those cases for which the common beam theory holds, and so are usually neglected.

Sketches (g), (h) and (i) in Table I, with yielding supports, can be considered simultaneously by means of the schematic in Fig. 3(A). The machine W will be considered mounted at midspan. When a simple support is used at either end, Sketches (g) and (h), the corresponding spring stiffnesses k_o and/or k_3 are zero. In fact, (f) could also have been included in this analysis by letting both k_2 and k_3 be zero.

The value of k to be used in Eq (1) for the machine supported as in Fig. 3(A) is obtained by superposition of the deflections shown in (B) through (F) of this figure. The deflection d under W is:

$$d = \frac{W}{4}\left(\frac{1}{k_1} + \frac{1}{k_2} + \frac{L^3}{12EI}\right) - \frac{L^2}{16EI}(M_1 + M_2) - \left(\frac{M_1 - M_2}{2L}\right)\left(\frac{1}{k_2} - \frac{1}{k_1}\right) \qquad (10)$$

The stiffness at W is:

$$k = \frac{W}{d} = 1\Big/\left[\frac{1}{4}\left(\frac{1}{k_1} + \frac{1}{k_2} + \frac{L^3}{12EI}\right) - \frac{L^2}{16EI}\left(\frac{M_1 + M_2}{W}\right) - \left(\frac{M_1 - M_2}{2LW}\right)\left(\frac{1}{k_2} - \frac{1}{k_1}\right)\right] \qquad (11)$$

The moments M_1 and M_2 are unknown. They are easily determined, however, from the fact that each end moment is counteracted by deflection loads in springs k_o and k_3. These end moments and the net slopes θ_L and θ_R (left and right end) must be compatible.

The net slope at the left end is, by superposition:

$$\theta_L = \theta_1 + \theta_2 - \theta_3 - \theta_5 - \theta_7 \quad (12)$$

Similarly,

$$\theta_R = -\theta_1 + \theta_2 - \theta_4 - \theta_6 + \theta_7 \quad (13)$$

From Fig. 3 and from handbook values for the end slopes in bending:

$$\theta_1 = \frac{W}{2L}\left(\frac{1}{k_2} - \frac{1}{k_1}\right); \qquad \theta_2 = \frac{WL^2}{16EI};$$

$$\theta_3 = \frac{M_1 L}{3EI}; \qquad \theta_4 = \frac{M_1 L}{6EI}$$

$$\theta_5 = \frac{M_2 L}{6EI}; \qquad \theta_6 = \frac{M_2 L}{3EI};$$

$$\theta_7 = \left(\frac{M_1 - M_2}{L}\right)\left(\frac{1}{k_2} + \frac{1}{k_1}\right)$$

If the rotational stiffnesses of the end supports are labeled k_{tL} for the left end and k_{tR} for the right end, they are related to the springs shown in the schematic diagram as follows:

$$k_{tL} = 2k_o e^2; \qquad k_{tR} = 2k_3 e^2$$

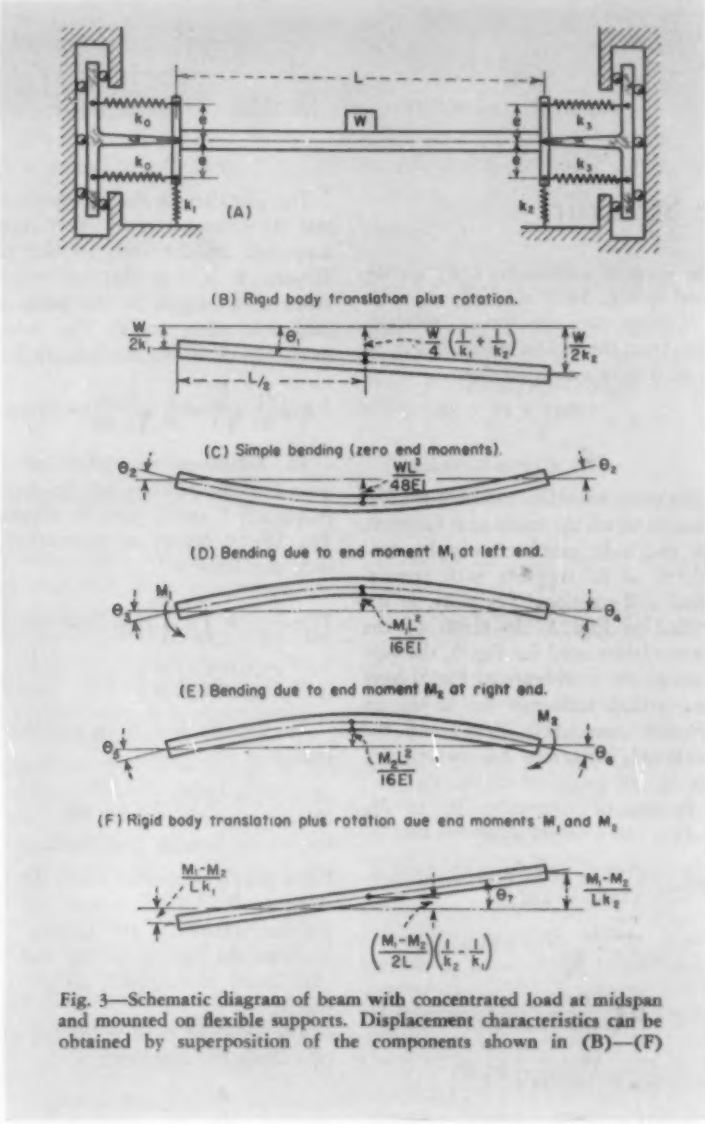


Fig. 3—Schematic diagram of beam with concentrated load at midspan and mounted on flexible supports. Displacement characteristics can be obtained by superposition of the components shown in (B)—(F)

Moments M_1 and M_2 are given by:

$$M_1 = k_{tL}\theta_L; \qquad M_2 = k_{tR}\theta_R \quad (5)$$

Thus:

$$M_1 = k_{tL}\left[\frac{W}{2L}\left(\frac{1}{k_2} - \frac{1}{k_1}\right) + \frac{WL^2}{16EI} - \frac{M_1 L}{3EI} - \frac{M_2 L}{6EI} + \left(\frac{M_2 - M_1}{L}\right)\left(\frac{1}{k_2} + \frac{1}{k_1}\right)\right] \quad (14)$$

$$M_2 = k_{tR}\left[\frac{W}{2L}\left(\frac{1}{k_1} - \frac{1}{k_2}\right) + \frac{WL^2}{16EI} - \frac{M_1 L}{6EI} - \frac{M_2 L}{3EI} + \left(\frac{M_1 - M_2}{L}\right)\left(\frac{1}{k_2} + \frac{1}{k_1}\right)\right] \quad (15)$$

These equations can be solved simultaneously for M_1 and M_2, from which d and k can be obtained in Eqs (10) and (11), and then the natural frequency from Eq (1).

To include the effect of the distributed weight of the beam on the natural frequency, the Rayleigh method can again be used. The deflection curve is the superposition of the forms shown in Fig. 3(B)—(F). From the left end to W, x measured to the right:

$$y_1 = \frac{W}{2k_1} + \frac{W}{2}\left(\frac{1}{k_2} - \frac{1}{k_1}\right)\frac{x}{L} + \frac{W}{48EI}(3L^2 x - 4x^3) - \frac{M_1}{6EI}\left(-3x^2 + \frac{x^3}{L} + 2Lx\right) - \frac{M_2}{6EI}\left(6L^2 + Lx - \frac{x^3}{L}\right) + \frac{M_1 - M_2}{Lk_1} - \frac{M_1 - M_2}{L}\left(\frac{1}{k_2} + \frac{1}{k_1}\right)x \quad (16)$$

From the right end to W, x measured to the left:

$$y_2 = \frac{W}{2k_2} - \frac{W}{2}\left(\frac{1}{k_2} - \frac{1}{k_1}\right)\frac{x}{L} + \frac{W}{48EI}(3L^2 x - 4x^3) - \frac{M_1}{6EI}\left(6L^2 + Lx - \frac{x^3}{L}\right) - \frac{M_2}{6EI}\left(2Lx + \frac{x^3}{L} - 3x^2\right) - \frac{M_1 - M_2}{Lk_2} + \frac{M_1 - M_2}{L}\left(\frac{1}{k_2} + \frac{1}{k_1}\right)x \quad (17)$$

The kinetic energy is given by:

$$T = \frac{2\pi^2 f_o^2}{g}\left[w\int_0^{L/2} y_1^2\,dx + w\int_0^{L/2} y_2^2\,dx + Wd^2\right] \quad (18)$$

The potential energy is $U = \frac{1}{2}Wd$.

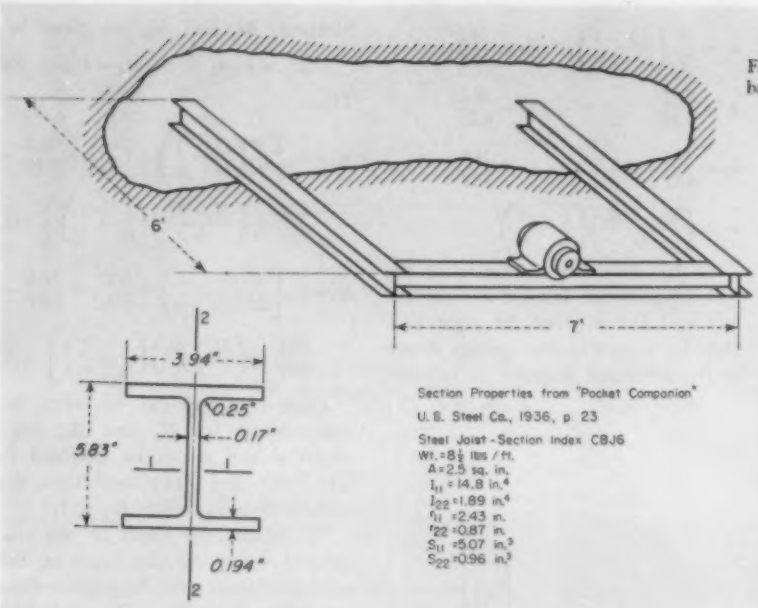
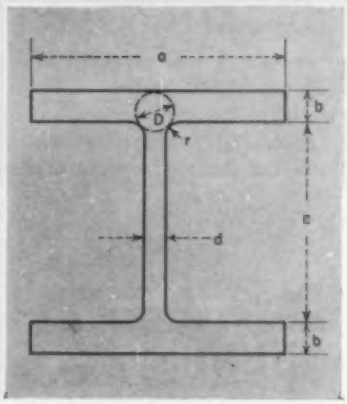


Fig. 4—Machine mounted on steel balcony built into a wall.

Fig. 5—Section nomenclature for torsional rigidity formula.



Application to Composite Structure

To illustrate the superposition method as applied to a composite structure, suppose a 1,000 lb machine to be supported on the balcony-type structure shown in Fig. 4, consisting of three lengths of steel joist, section index CBJ6, welded together, and fixed rigidly into a wall. The problem is to find the natural frequency of the machine bolted directly to this balcony, to determine the effect of balcony weight, and to study the isolation effectiveness of the system.

The vertical deflection of the end of each cantilever is:

$$d = \frac{\frac{1}{2}WL^3}{3EI} = \frac{500\times6^3\times12^3}{3\times3\times14.8\times10^7} = 0.14 \text{ in.}$$

The two cantilevers also act as torsion bars, since the load W is offset from their planes of bending. The torsional rigidity of such a section is given by (see sketch *C*, Table I):

$$k_t = \frac{KG}{L}$$

For an H-section, Roark, "Formulas for Stress and Strain," Case 17, p. 171, 2nd Ed., McGraw-Hill Book Co., New York, 1943, gives for K:

$$K = 2ab^2\left[\frac{1}{3} - 0.21\,\frac{b}{a}\left(1 - \frac{b^4}{12a^4}\right)\right] + \frac{1}{3}\,\alpha t^3 + \frac{2t}{t_1}\left(0.15 - 0.1\,\frac{r}{b}\right)D^4 \qquad (19)$$

The symbols used in Eq (19) are defined in Fig. 5.

Making the appropriate substitutions from the section shown in Fig. 4, $K = 0.0348$ in.⁴ Therefore,

$$k_t = \frac{0.0348\times12\times10^6}{6\times12} = 5.8\times10^3 \text{ in.lb./radian.}$$

Focusing attention on the 7 ft cross beam to which the machine is fastened, the two side members may be considered as its supports with translational and rotational flexibility, as described in Fig. 3. In terms of the nomenclature used for Fig. 3, the supports of the cross beam of Fig. 4 have the vertical stiffnesses $k_1 = k_2 = 500/0.14 = 3{,}560$ lb/in., and the rotational stiffnesses $k_{tR} = k_{tL} = 5.8\times10^3$ in.lb/rad $= k_t$.

Because of symmetry, $M_1 = M_2$ and the end moment equations are:

$$M_1 = k_t\left(\frac{WL^2}{16EI} - \frac{M_1L}{2EI}\right) = \frac{k_tWL^2}{8(2EI + k_tL)} = 5.76 \text{ in.-lb.}$$

$$d = \frac{1000}{4}\left(\frac{2}{3560} + \frac{84^2}{12\times3\times10^7\times14.8}\right) - \frac{84^2}{16\times3\times10^7\times14.8} \qquad (11.52)$$

$$= 0.14 + 0.0278 - 0.00001 = 0.168 \text{ in.}$$

The joists are so flexible torsionally that the cross bar is in effect simply supported on the ends of the cantilevers. It is clear that the twisting moment developed in the joists has negligible effect on d. The natural frequency of W on the balcony is:

$$f_o = \frac{1}{2\pi}\sqrt{\frac{g}{d}} = \frac{1}{2\pi}\sqrt{\frac{386}{0.168}} = 7.64 \text{ cps}$$

To determine the effect of the weight of the balcony on the natural frequency, T and U must be obtained. The kinetic energy of translation of each cantilever is:

$$T_t = \frac{2\pi^2f_o^2}{g}\,w\int_0^{L_1}\left[\frac{W}{12EI}\,(3L_1x^2 - x^3)\right]^2dx = \frac{\pi^2f_o^2w^2W^2L_1^7}{72gE^2I^2}\left(\frac{33}{35}\right) \qquad (19)$$

The angular twist at the end of each cantilever is:

$$\theta_o = \frac{M_1}{k_t} = \frac{5.76}{5.8\times10^3} = 0.993\times10^{-3} \text{ radians}$$

For a simply supported beam the end slope is $WL^2/16EI$, which for this problem is 0.993×10^{-3} radians. This confirms the earlier finding that the cross beam is essentially simply supported.

The angle of twist θ for any position along the cantilever is

$$\theta = \frac{\theta_o}{L_1}(x) = 1.38(10^{-5})(x)$$

The kinetic energy of rotation is

$$T_r = \frac{Jw}{2gA}\,\omega^2 \int_0^{L_1} \theta^2\,dx$$

$$= 0.507\,\frac{\pi^2 f_o^2}{g}\,JwL_1^3 \qquad (20)$$

where A is the area of the beam cross section and J the polar moment of the section about the cg ($J = I_{11} + I_{22}$).

The kinetic energy of translation of the cross beam is:

$$T_b = \frac{4\pi^2 f_o^2}{g}\,w \int_0^{L_2/2} \left[\frac{WL_1^2}{6EI} + \frac{W(3L_2^2x - 4x^3)}{48EI}\right]^2 dx =$$

$$\frac{\pi^2 f_o^2 w W^2 L_2}{18gE^2I^2}\left(L_1^6 - \frac{3L_2^6}{2240} + \frac{5L_1^3L_2^3}{32}\right) \qquad (21)$$

The kinetic energy of translation of the machine is:

$$T_m = \frac{2\pi^2 f_o^2}{g}\,(W)(0.168)^2 \qquad (22)$$

The total kinetic energy of the structure at maximum velocity is:

$$T = 2T_t + 2T_r + T_b + T_m \qquad (23)$$

$$= \frac{\pi^2 f_o^2}{g}\,(0.948 + 0.0004 + 2.95 + 56.5)$$

$$= 60.4\,\frac{\pi^2 f_o^2}{g} \qquad (24)$$

Eq (24) shows that the twisting of the cantilevers contributes negligibly to the kinetic energy. The potential energy at extreme displacement is:

$$U = \tfrac{1}{2} \times 1000 \times 0.168 = 84 \text{ in.-lb}$$

Hence,

$$f_o = \sqrt{\frac{84 \times 386}{9.87 \times 60.4}} = 7.38 \text{ cps} \qquad (25)$$

This is about $3\frac{1}{2}$ percent decrease in frequency over the case neglecting the effect of distributed weight of the structure.

Table II – Equivalent Weights of Standard Beams

Beam Type	Percent of Beam Weight to be added to W
(a) Cantilever, end weight	24
(b) Simple beam, central weight	49
(c) Built-in beam, central weight	38
(d) Beam, one end fixed, other simply supported, central weight	46

Equivalent Weight of Structure

Each cantilever weighs 51 lb and the cross beam 59.5 lb. In analyses such as these it is often the practice to take into account the influence of the weight of the structure on the natural frequency of the machine by adding to the machine weight a certain percentage of the weight of the structure. This is called the equivalent weight of the structure. Table II shows equivalent weight factors for common beams. They are between 24 and 49 percent of beam weight for the standard forms shown.

An equivalent weight can be determined for the balcony of Fig. 4. The portion of each beam to be concentrated at the machine location is that which will have the same kinetic energy at this location as the kinetic energy of the entire beam. Thus, for each cantilever, the ratio q of equivalent weight to actual weight is found from:

$$T_t = \frac{\pi^2 f_o^2}{2g}\,0.948 = \frac{51}{2g}\,q4\pi^2 f_o^2 0.168^2$$

From this, $q = 0.165$, or only 16.5 percent of each cantilever weight is to be added to W. This percentage is smaller than that given in Table II because the weight is being transferred to a point which has a larger amplitude of motion than does the end of the cantilever itself.

For the cross beam,

$$T = \frac{\pi^2 f_o^2}{g}\,2.95 = \frac{59.5}{2g}\,q\,4\pi^2 f_o^2 0.168^2$$

Here, $q = 0.88$.

In this case 88 percent of the weight of the cross beam must be added to W. This is much larger than the value given in Table II for a simply supported beam because the ends of the beam move almost as much as does the center.

The effective weight of the balcony at the machine location is, therefore, $W_e = 2\text{x}0.165\text{x}51 + 0.88\text{x}59.5 = 69$ lb.

This can be checked by substituting Eq (1). The value should be the same as from Eq (25). Thus,

$$f_o = \frac{1}{2\pi}\sqrt{\frac{1000 \times 386}{0.168 \times 1069}} = 7.38 \text{ cps}$$

Vibration Isolation of the Machine

Excluding damping effects, which are usually small except at resonance, the transmissibility of vibratory forces from the machine to wall is given by

$$r = \frac{1}{\left|1 - \left(\frac{f}{f_o}\right)^2\right|} = \frac{1}{\left|1 - \left(\frac{f}{442}\right)^2\right|} \qquad (26)$$

Usually f is the rotational speed of the machine, but in the case of internal combustion engines, compressors, and the like, subharmonics and harmonics of the speed might be present. In Eq (26), both of the frequencies, f and f_o are expressed in cycles per minute in the interests of convenience.

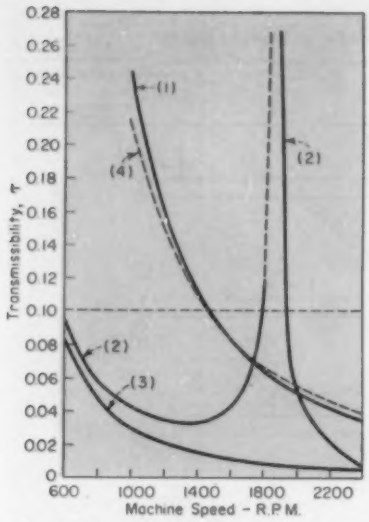


Fig. 6—Transmissibility curves for machine on balcony of Fig. 4

Suppose the machine is to operate over a speed range of 600 to 2,400 rpm. The transmissibility in accordance with Eq (26) has been plotted over this speed range as Curve (1) in Fig. 6. If the design requirement is that the transmissibility should not exceed 0.1 over this speed range, it is evident that this machine cannot operate at speeds below 1,500 rpm. To lower the transmissibility, the conventional practice would be to put soft mounts under the machine. It might be erroneously concluded that if the mounts are soft enough to provide a transmissibility of 0.1 at 600 rpm it would be safe to operate at any higher speed.

The complicating factor, however, is the balcony weight and flexibility. By using soft mounts under the machine, the system has been converted from essentially a one-degree-of-freedom system to a two-degree-of-freedom system. Although the equivalent structural weight only amounts to 69 lb as compared to a machine weight of 1,000 lb, and the structural stiffness is 1.000/0.168 = 5,950 lb-in. as compared to a mount stiffness of only 930 lb/in., see Eq (27), the higher natural frequency of the combined system falls within the operating range of the machine and so introduces a high degree of transmissibility into the support.

To get a τ of 0.1 at 600 rpm through the machine mounts, the machine should have a natural frequency on these mounts given by the equation:

$$0.1 = \frac{1}{\left|1 - \left(\frac{600}{f_o}\right)^2\right|}$$

From this $f_o = 181$ cpm.

The isolation mount stiffness is from Eq (1):

$$\frac{f_o}{60} = \frac{1}{2\pi}\sqrt{\frac{kg}{W}}; \text{ or, } k = 930 \text{ lb/in.} \quad (27)$$

The two natural frequencies of the system are:

$$f'_o = \frac{1}{2\pi}\left[\frac{g}{2}\left(\frac{k+k_s}{W_e} + \frac{k}{W}\right) - \frac{g}{2}\left\{\left(\frac{k+k_s}{W_e} + \frac{k}{W}\right)^2 - \frac{4kk_s}{W_eW}\right\}^{1/2}\right]^{1/2}$$

$$f''_o = \frac{1}{2\pi}\left[\frac{g}{2}\left(\frac{k+k_s}{W_e} + \frac{k}{W}\right) + \frac{g}{2}\left\{\left(\frac{k+k_s}{W_e} + \frac{k}{W}\right)^2 - \frac{4kk_s}{W_eW}\right\}^{1/2}\right]^{1/2}$$

Under the influence of the exciting force $F_o \sin 2\pi ft$, both W and W_e will oscillate at the frequency f. If the amplitude of vibration of W_e is A_e, the amplitude of the force transmitted to the wall in Fig. 4 is $5{,}950A_e$ lb, and the transmissibility of the entire system is $\tau = 5{,}950A_e/F_o$.

In terms of the uncoupled natural frequencies f_o and f_{oe} the transmissibility is

$$\tau = \frac{1}{\left|\left(1 - \frac{f^2}{f_o^2}\right)\left(1 + \frac{k}{k_s} - \frac{f^2}{f_{oe}^2}\right) - \frac{k}{k_s}\right|}$$

where $f_o = \frac{30}{\pi}\sqrt{\frac{kg}{W}} = 181$ cpm is the uncoupled natural frequency of W on k, and $f_{oe} = \frac{30}{\pi}\sqrt{\frac{k_sg}{W_e}} = 1743$ cpm is the uncoupled natural frequency of W_e on k_s.

Substituting numerical values:

$$\tau = \frac{1}{\left[1 - \left(\frac{f}{181}\right)^2\right]\left[1.156 - \left(\frac{f}{1743}\right)^2\right] - 0.156}$$

The transmissibility for this case is shown plotted as Curve (2) in Fig. 6. As shown by this curve, the effect of balcony stiffness and weight is of paramount importance if the machine operates around 1,850 rpm.

If, as is sometimes done, the weight of the structure is neglected, but its flexibility is added to that of the isolation mounts, the resultant stiffness k_r under the machine would be given by:

$$\frac{1}{k_r} = \frac{1}{k} + \frac{1}{k_s} = \frac{1}{930} + \frac{1}{5950}, \text{ or } k_r = 804.$$

The corresponding natural frequency of the machine would be:

$$f_o = \frac{30}{\pi}\sqrt{\frac{804 \times 386}{1000}} = 168 \text{ cpm.}$$

The transmissibility in accordance with Eq (26) would then be shown by Curve (3) in Fig. 6.

The dangers of using such method of analysis are obvious by comparing Curves (3) with (2), described previously.

Transmissibility Due to Unbalance

In defining τ above, the ratio of force on foundation to force on machine was taken. When the force on the machine is due to unbalance, the force varies with the square of the speed, so that for a given constant value of transmissibility defined as above, the force into the foundation is less at low speeds than it is at high speeds, the force ratio being equal to the square of the speed ratio.

Consequently, a higher transmissibility would be allowed at lower speeds, or, conversely, a lower transmissibility would be required at the higher speeds.

For example, suppose in the system represented by Fig. 4 the force excitation is due to rotational unbalance and that the allowable force into the foundation is P. Referring to Curve (1) in Fig. 6 suppose the force P occurs at a transmissibility of 0.083 at 1,600 rpm. The transmissibilities allowed at all the other speeds from 600 to 2,400 rpm can be calculated readily from the following equation:

$$\tau \text{ allow.} = 0.083\left(\frac{1600}{f}\right)^2$$

Curve (4) in Fig. 6 shows this transmissibility expression. As expected, the transmissibility values are less than those given by Eq. (26) below 1,600 rpm. At operating speeds above 1,600 rpm, the new transmissibility values are higher.

Fig. 1—(A) Typical pneumatic-electric relay. The pressure range is 0-15 psi with an adjustable differential from 1.5 to 13 psi. Snap-switch rating is 7.4 amps full load current or 44.4 amps locked rotor current at 115 v a-c. (B) Electric-pneumatic relay. Unit is available in all standard voltages and frequencies up to 250 v a-c. and will handle control air pressures up to 15 psi. Air connections are ¼ in. pipe taps or can be adapted for ¼ in. tubing.

Air-Electric Relays Link Pneumatic and Electric Control Systems

To control an electrical circuit with a pneumatic signal or a pneumatic circuit with an electrical signal air-electric relays can be used. Here are the details covering operation, types and application circuits for these relays.

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PNEUMATIC-ELECTRIC and electric-pneumatic relays are used in control applications where interlocking between pneumatic and electric devices is required. When a pneumatic control device must actuate a signal or alarm in addition to its control function; or when an electric timing device is required to initiate the operation of a pneumatic control system, these relays are the "linkage" between the pneumatic and electrical components.

In a pneumatic-electric relay, Fig. 1(A), air pressure operates a linkage and switch mechanism to energize or de-energize an electric circuit; while the electric-pneumatic relay, Fig. 1(B), energizes or de-energizes pneumatic circuits on the basis of an electrical impulse. A more common terminology for these devices is electrically actuated or solenoid valve (electric-pneumatic) and pressure switch (pneumatic-electric); however, the relay designation more clearly defines their application in control systems.

Electric-Pneumatic Relays

A schematic diagram of this type relay is shown in Fig. 2. The solenoid coil actuates the relay lever which is pivoted to operate the spring loaded

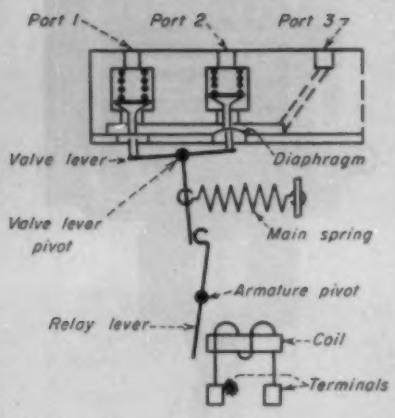


Fig. 2—Schematic of electric-pneumatic relay. The valve operating projections on the valve lever actuate the valves under ports 1 and 2 through a diaphragm. The diaphragm seals the air chamber from the effects of the atmosphere.

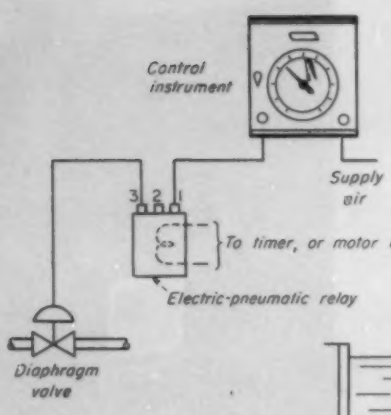


Fig. 3—Basic application circuit for electric-pneumatic relay. An electrical control circuit controls the functioning of a diaphragm valve by energizing or de-energizing the relay.

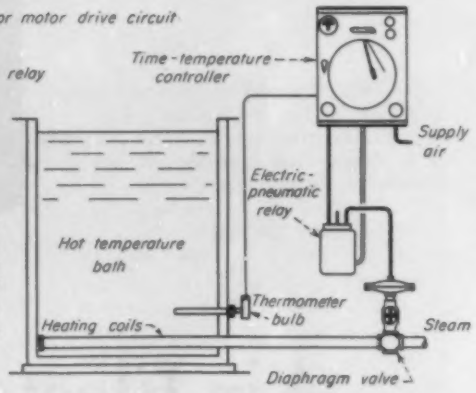


Fig. 4—Time and temperature controlled bath using electric-pneumatic relay to shut off pneumatic signal to diaphragm valve and stop flow of steam to bath at the end of a preset timed period. Relay is connected in the normally-open position.

valves located in the chambers beneath ports 1 and 2. When the relay is de-energized (as shown) the valve beneath port 2 is open and air can flow between ports 2 and 3. When the relay is energized the coil pulls in the lower end of the relay lever, overcoming the main spring and rotating the valve lever around its pivot. This opens the valve under port 1 and closes the valve under port 2. Air flow is thus between ports 3 and 1.

In a typical application, Fig. 3, the electric-pneumatic relay is installed in the controlled air line from a pneumatic control device to a diaphragm valve. When the relay is de-energized, ports 2 and 3 are connected and the valve diaphragm is vented to the atmosphere. However, when the timer or control circuit energizes the relay, air flow is from the instrument through ports 1 and 3 to the diaphragm valve. The valve is positioned in accordance with the pneumatic signal from the control instrument.

This type electric-pneumatic relay actually corresponds to a single-pole, double-throw standard electrical relay with one normally-open and one normally-closed contact. When used as in Fig. 3, the relay is normally open since in a de-energized condition the diaphragm is vented to the atmosphere. By connecting the line from the control instrument to port 2 instead of port 1, the relay would be operating normally closed.

A schematic circuit of a time and temperature controlled bath using an electric-pneumatic relay to relay an electrical control signal to a pneumatic circuit is shown in Fig. 4. The temperature controller contains an electric timer wired to the electric-pneumatic relay. At the beginning of a cycle the required bath temperature and the length of time this temperature must be maintained are set in the controller. During the timed period, the circuit to the relay is energized completing the pneumatic circuit from the controller to the diaphragm valve which admits a controlled amount of steam to the heating coils. At the end of this period, the relay is de-energized, blocking the pneumatic signal from the controller and venting the diaphragm valve to the atmosphere. The diaphragm valve is of the spring-to-close, pressure-to-open type and shuts off the steam supply to the bath.

Pneumatic-Electric Relays

Pneumatic-electric relays, Fig. 5, are used where a pneumatic signal must actuate an electrical device. Variations in pressure cause movement of the bellows assembly which actuates the operating lever and the enclosed nonmagnetic snap switch. The operating pressure and differential between the opening and closing points depend on spring setting.

Depending on how the circuit connections are made, the snap switch will either close or open the circuit on an increase in pressure, or give single-pole, double-throw switching, breaking one circuit and making another, when the pressure exceeds the set point value.

The set point is adjusted by varying the tension in the pressure adjustment spring. This spring opposes the motion of the operating lever so that the bellows movement will actuate the snap switch at the proper pressure valve.

The differential is set by adjusting the tension in the differential adjustment spring. The effect of this spring is added to that of the pressure adjustment spring in opposing the motion of the operating lever. The differential setting affects operation as follows: if the connections to the switch are made to break the circuit on pressure rise, then with a differential setting of 3 psi and a pressure setting of 9 psi, the relay will break the circuit at 12 psi and make the circuit at 9 psi.

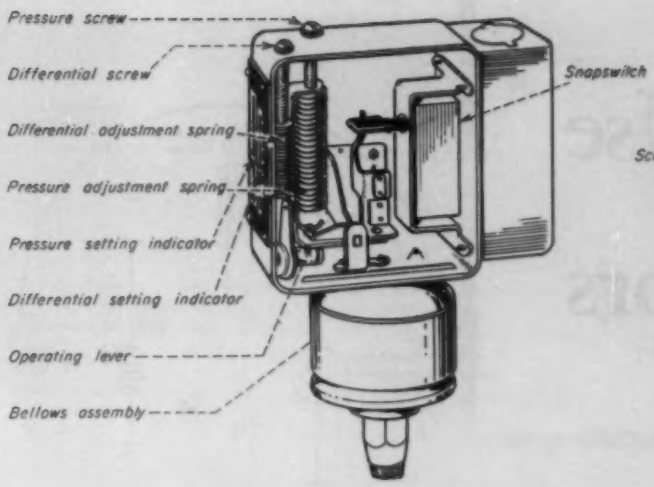
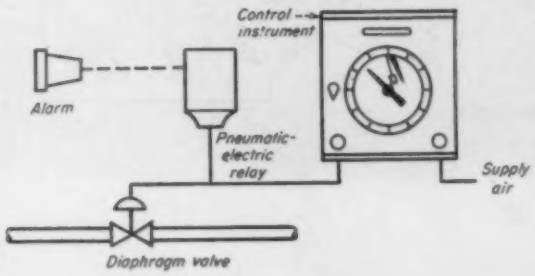


Fig. 5—Typical pneumatic-electric relay. Operating pressure is set by the pressure screw according to reading of pressure setting indicator, while the differential is adjusted in a similar manner with the differential screw and differential setting indicator.

Fig. 6—Signal alarm application of pneumatic-electric relay. Where allowable limits are established for the pneumatic signal from the controller and thus for valve stroke, relay gives indication above or below limits.



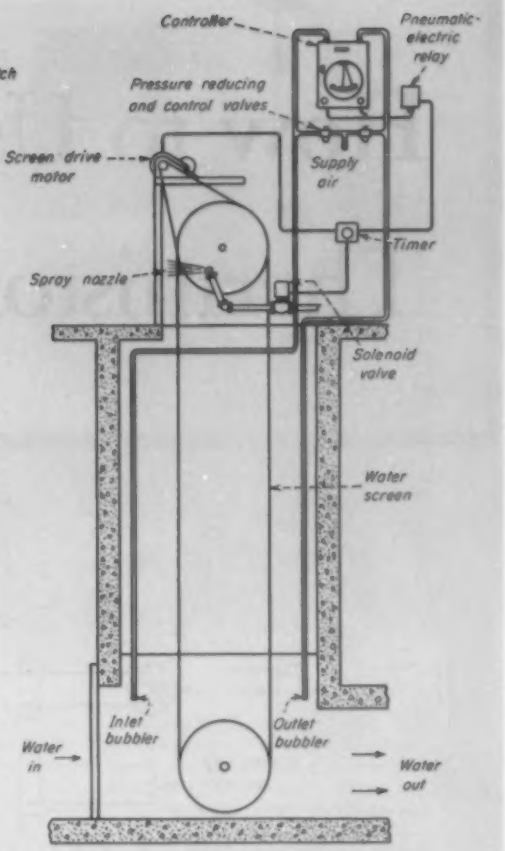


Fig. 7—Control circuit for water screening system using pneumatic-electric relay. The difference between bubbler pressures is fed to a pneumatic controller which delivers an output pressure signal to the relay that is proportional to the differential. Relay energizes screen motor.

With a pressure setting of 10 psi and a differential setting of 1.5 psi, the relay will break the circuit at 11.5 psi and make it at 10 psi.

A typical application of a pneumatic-electric relay is shown in Fig. 6. The relay is installed in the controlled air line from a temperature controller to a diaphragm control valve. When the pneumatic signal from the controller exceeds the pressure at which the relay is set, the circuit closes, energizing the alarm. This arrangement is used to give either low limit or high limit signals in conjunction with control operations.

In Fig. 7 is shown a pneumatic-electric relay used in the control circuit of a device for removing debris from a water supply intake. The water screens form an endless belt passing through the water intake and up past the cleaning syrays. The accumulation of debris on the upstream side of the screen causes the water level on the downstream side of the screen to fall. This difference in level between the upstream and downstream sides is utilized to actuate the control system, which operates to clean the screens and thereby maintain the intake head of the water supply.

The difference in pressure between that in the inlet bubbler and that in the outlet bubbler is proportional to the decrease in level of the downstream water and to the amount of debris that has collected. The controlled air output from the controller to the relay increases as the differential between the bubbler pressures increase, finally causing the relay to close. The relay energizes a timer which starts the drive motor and opens the solenoid valve to admit water to the spray nozzle.

At the end of the timed period the motor stops and the solenoid valve is de-energized. If the accumulation has not been cleared sufficiently the timer is energized again, and the sequence is repeated until the output of the controller drops below the set point of the relay.

How to Use Thermistors

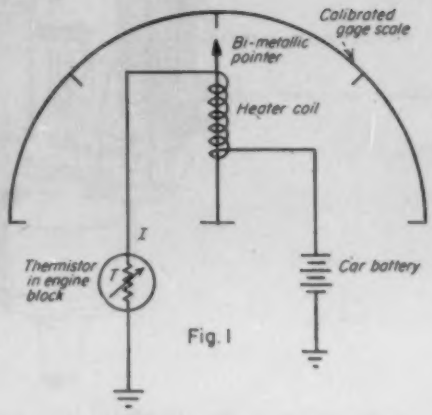


Fig. 1

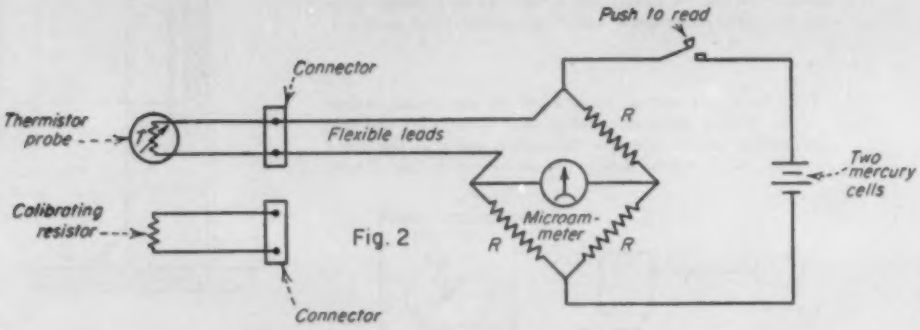


Fig. 2

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Basic application circuits based on temperature sensitive characteristics of thermistors. Also includes data on other uses not concerned with temperature measurement or control.

THE CHARACTERISTICS, types and mounting arrangements of thermistors were covered in "Which Type Thermistor," see *Product Engineering*, March 1954, page 182. Since these devices are fundamentally temperature sensitive resistors, most applications can be classified under temperature measurement, control or compensation. Although other applications are covered in the following material, they are generally specific to a particular problem.

Thermistors are used for temperature measurement because of their high sensitivity and ease of remote indication.

A thermistor bridge circuit operating into an inexpensive microammeter can produce full-scale deflection with only a one degree Centigrade change in temperature. The resistance of the thermistor can be chosen so high that no correction is required for the resistance of leads of any length. No cold junction or specially compensated meter is required.

The thermistor can also be adapted to other more remote means of telemetering. For example, it can be used as the frequency determining element in a simple *R-C* oscillator for data transmission by means of telephone lines. The thermistor is the standard temperature sensing device used in weather balloons in which the data is transmitted back to the weather station by means of a tiny transmitter.

The thermistor is also applicable to problems in which ultra-high sensitivity is not required. One manufacturer of automobiles uses a thermistor as the engine-temperature sensing device to operate a bi-metallic indicator on the instrument panel. Fig. 1 shows a simplified diagram of this indicator.

The small size, and resultant short time-constant, of certain thermistor types is an advantage in some temperature measuring applications. A recently designed thermistor clinical thermometer has a total response time

Fig. 1—Thermistor used as automobile engine-temperature sensing device. As engine temperature increases, themistor resistance decreases and current, I, increases. Heater coil temperature increases and bi-metallic pointer indicates engine temperature on calibrated scale.

Fig. 2—Basic resistance bridge circuit using thermistor as one leg. This particular arrangement is used in a clinical thermometer developed by Wrenco Inc. The microammeter has a 100μa, 500 ohm movement and is calibrated to read 95 to 106 F. Unit is size of ordinary light-meter. Built-in calibrating resistor is used to check voltage.

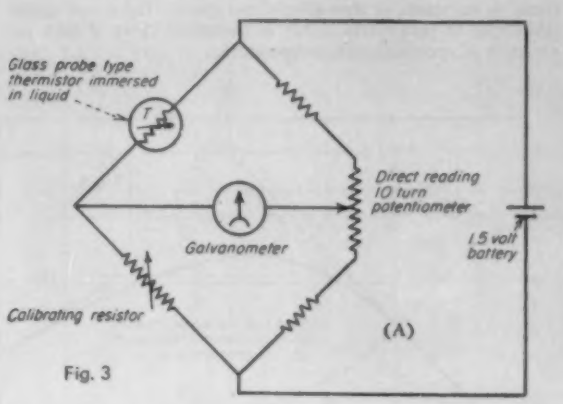


Fig. 3

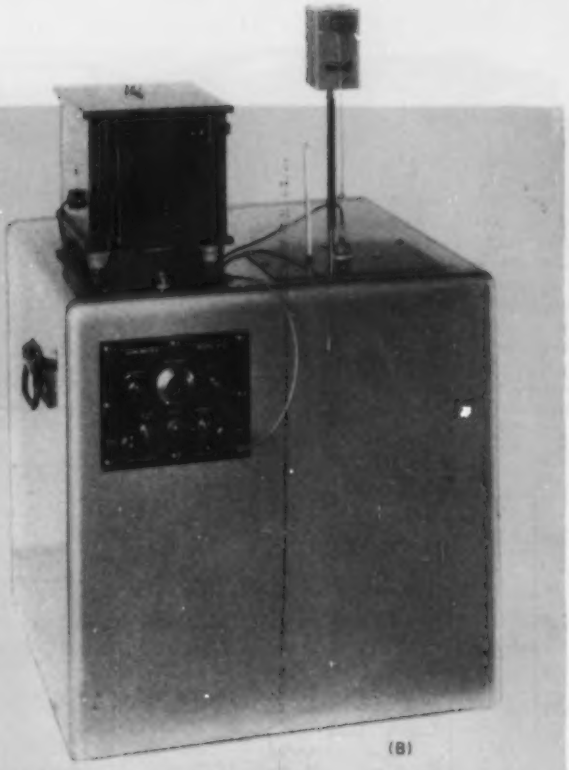


Fig. 3—(A) Null-balance bridge circuit using thermistor. Advantage of this arrangement over that shown in Fig. 2 is that in null circuit calibration is independent of battery voltage. (B) Osnometer for testing biological solutions by freezing point determination method manufactured by Fiske Associates, Inc. Unit uses circuit shown in (A) and will measure freezing points from 0C to —1.86C to an accuracy of 0.001C.

of about 15 sec as compared to a response time of about 3 min for standard thermometers. The basic circuit for this instrument is shown in Fig. 2. This type of resistance bridge circuit with a thermistor as one leg can be applied to many applications. Any of the thermistor types can be used depending on the specific requirements.

Differential temperatures can be measured by using two thermistors as opposing arms in a bridge circuit. This has been applied to many high accuracy applications; for example, nuclear cloud chambers where differences of 0.001 C can be detected.

For high precision temperature measurements a null-balance type circuit is used, Fig. 3(A). Since the reading is taken from the potentiometer setting when the galvanometer nulls, the calibration is independent of battery voltage. In addition, this arrangement basically measures the ratio of the thermistor resistance at the operating point to its resistance at some reference temperature. Variations in initial resistance of the thermistor at the reference temperature (for example, OC) can be taken care of by adjusting the calibrating resistor with the thermistor at the reference temperature. Thus thermistors with variations in resistance from unit to unit will operate satisfactorily in this circuit. In the event of thermistor aging, the instrument can be recalibrated in the field by the same procedure.

The circuit has the advantage that when thermistor aging does occur, it affects the resistance of the thermistor at any given temperature, but does not measurably affect the ratio of the thermistor resistance at two different temperatures.

One application of this circuit is the osmometer, Fig. 3 (B). An osmometer is a device for testing biological solutions by the freezing point determination method. A glass probe thermistor is used to measure the freezing point to an accuracy of about 0.001 centigrade.

Temperature Control

While a thermistor and its required associated equipment are more expensive than a standard thermostat, the thermistor has certain advantages in temperature control applications. The most important advantage is the ease of adjustment of the controlling point.

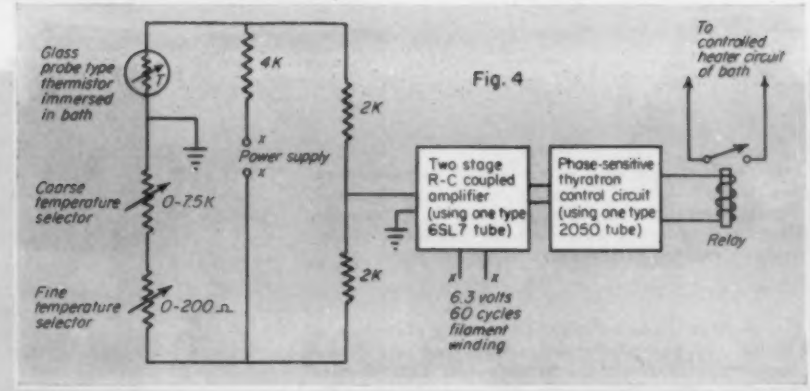


Fig. 4—On-off regulating circuit for controlling temperature of liquid bath. Variable output of thermistor circuit is amplified in two stage electronic amplifier which feeds phase-sensitive thyratron circuit to operate heater relay. Regulating point can be selected by varying the coarse and fine selector resistors. Temperature can be maintained within about 0.005C.

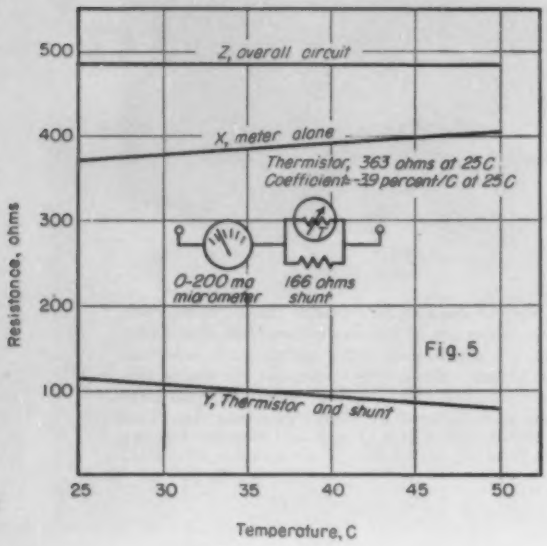
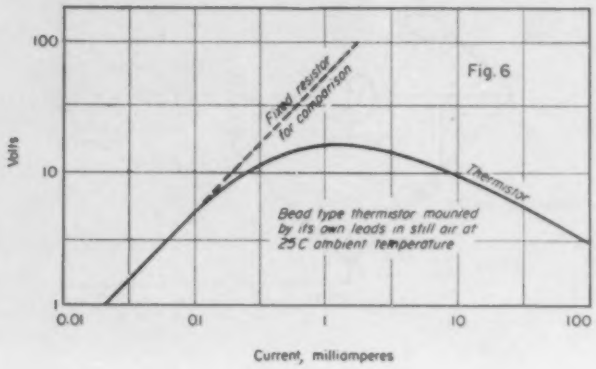


Fig. 5—Straight line thermistor-shunt compensating circuit for Weston Model 461 microammeter. Curve *X* shows increase in resistance of meter coil with temperature. Curve *Y* shows decrease in resistance of thermistor-shunt circuit. Equal and opposite slopes of two curves result in composite curve *Z* with no variation of resistance with temperature.



One manufacturer of electric kitchen ranges uses a bead-type thermistor to control the temperature in one of the top heaters (not in the oven). By means of front panel control, various cooking temperatures can be selected and maintained.

If the thermistor is chosen with enough area or heat dissipating capacity so that considerable power can be applied to it, a controlling relay can be operated directly. This form of auxiliary apparatus is used with thermistors in aircraft cabin temperature controls and de-icing equipment.

If a small thermistor must be used, or if closer control must be achieved, then vacuum tube controllers are required, Fig. 4. When used with vacuum tubes, high resistance thermistors can be chosen so that the input signal to the tube is several volts per degree Centigrade. In addition, by exciting the thermistor bridge with alternating current, the output signal is a-c and can be amplified without the use of a modulator or troublesome d-c amplifier.

In more complicated systems where servo techniques are necessary because of long time constants within the system to be controlled, thermistors serve as ideal sensing elements because a thermistor bridge circuit develops an output which is proportional to the temperature error existing in the system at any time.

One type of thermistor temperature control system uses neither tubes nor relays. This arrangement can be used to control the temperature of small ovens. A thermistor network exposed to the outside ambient temperature directly controls the power input to the oven heater in accordance with outside temperature. The power supplied is always just sufficient to maintain the oven at some pre-selected temperature somewhat higher than the highest ambient temperature normally encountered. In this application, the principal advantage of a thermistor circuit over thermostats is the absence of moving contacts and the resulting high reliability and long life.

Differential controls of the anticipating type can be constructed using thermistors in two legs of a bridge. This system has found application in aircraft cabin temperature control.

Fig. 6—Steady-state voltage current curve for typical thermistor. Dotted comparison curve is for conventional fixed resistor with linear relationship. Negative temperature coefficient causes drooping curve for thermistor.

Fig. 7—Current-time characteristic when a high voltage is suddenly applied to a thermistor and fixed resistor in series showing time-delay property. As the thermistor heats and its resistance decreases, the current flow gradually increases to its steady state value. This arrangement can be used for protecting the cold filaments of electron tubes from overvoltage when the power is turned on.

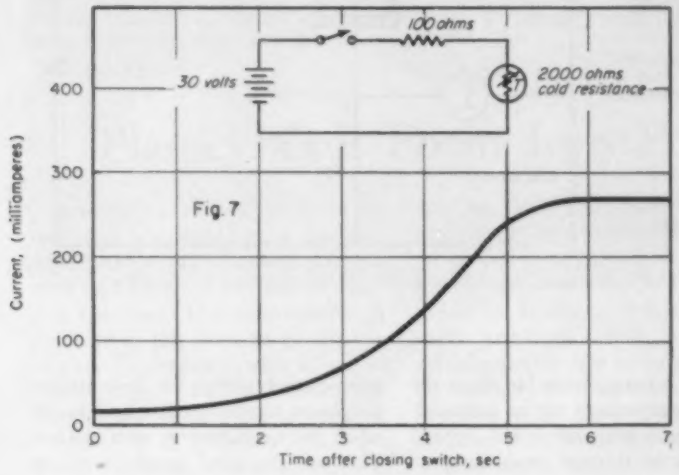


Fig. 8—Portable type combustion analyzer using thermistor sensing element for measuring percent CO_2 and draft.

Temperature Compensation

A thermistor can be used to compensate an electrical device for undesired variations in performance that are caused by temperature changes in some other component. The most common occurrence of this kind is the change in resistance of a copper coil with temperature. For example, millivoltmeters are subject to errors in calibration with changes in temperature, and consequently resistance, of the moving coil. A suitable thermistor network (usually consisting of a thermistor and associated shunt resistor) can be connected in series with the coil so that the overall resistance is constant despite temperature changes.

In a resolver (angular-position data transmitter) manufactured by the Control Engineering Corporation, bead-type thermistors are imbedded directly in the coils of the unit and not only compensate for changes in resistance of the copper windings, but also simultaneously correct for variations in the magnetic properties of the core material. Variations in the "*Q*" of the *IF* transformers of certain Air Force radio receivers is prevented by the inclusion of a suitable thermistor in the circuit.

The compensation curves for the copper coil of a microammeter are shown in Fig. 5. In this application, the thermistor compensates for a straight-line variation of resistance with temperature. While this type of linear correcting network is usually satisfactory for metals, other devices and materials exhibit nonlinear variations of resistance with temperature and require nonlinear correcting networks. Many measurements in the chemical field, such as conductivity and *pH*, are temperature dependent and require correction. Other semiconductor devices such as transistors, and varistors (Thyrite) require temperature compensation in critical applications. A Navy nuclear radiation survey meter uses a thermistor to compensate for the temperature dependence of photomultiplier tubes.

In battery chargers, the proper point to switch from a high charging rate to a low rate depends on battery temperature. The Berg Gibson Manufacturing Co. uses a thermistor in series with a voltage-sensitive relay to perform this function in their charger. The thermistor circuit energizes the relay at the proper voltage in accordance with temperature.

In a given application, the nature of the resistance-temperature curve required for compensation can usually be determined by experimentation using the resistance substitution method. The required thermistor network can be selected on the basis of this curve together with information on maximum current and mounting specifications.

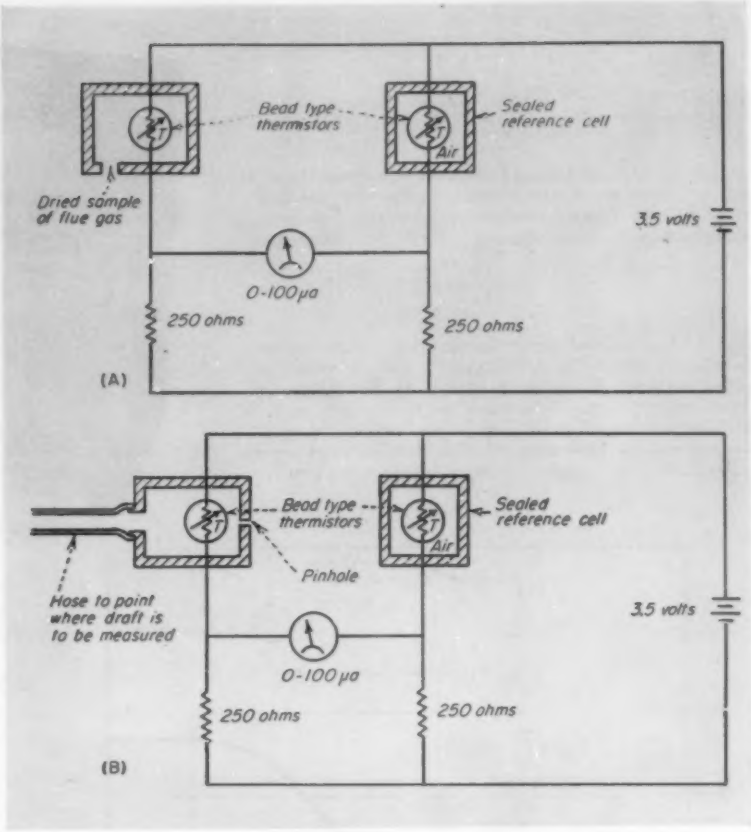


Fig. 9—Circuits used in analyzer shown in Fig. 8. In (A) is shown the circuit for measuring percent CO_2. This arrangement compares the resistance of two thermistors, one a sealed reference unit exposed to air and the other exposed to the flue gas sample. The thermal conductivity of the gas and thus the temperature of the thermistor varies with the percent CO_2. The resistance unbalance of the two thermistors can be read on the microammeter. The circuit shown in (B) is similar except that the temperature of the sensing thermistor varies with the air flow past it and thus with the draft being measured.

Other Applications

Since the temperature of a thermistor increases with an increase in the current flow, these devices can be used in many applications besides temperature measurement, control and compensation. Fig. 6 shows the steady-state voltage that results when various currents are passed through a thermistor. By Ohm's law this curve would be a straight line with a slope of one for an ordinary resistor. The drooping characteristic curve of the thermistor is caused by its decrease in resistance as its temperature and the current flow increase. Fig. 7 shows the current as a function of time when a sufficiently high voltage is suddenly applied to a thermistor in series with a fixed resistor. This principle is used in television receivers where a thermistor in series with the filament circuit protects the picture tube from current surges when the set is first turned on and all the filaments are cold. Tube life in all types of electronic circuits can be improved in this manner.

One manufacturer of solenoid valves used to control the flow of fuel oil to a furnace has added a disk-type thermistor in series with the solenoid winding. When the control thermostat calls for heat, power is applied simultaneously to the air-blower motor and to the solenoid valve. With a thermistor in the valve circuit, the operation of the valve is delayed a few seconds so that by the the time oil starts to flow the blower is running at full speed. This prevents sooty operation caused by oil flow while the blower is accelerating.

When a thermistor is electrically heated to a temperature far above the ambient temperature of its surroundings, its final temperature will depend partly on the thermal conductivity of its surroundings. This principle has been used in liquid level gages, vacuum gages, gas analyzers, flowmeters, anemometers and rate of climb indicators. Fig. 8 shows an analyzer for making CO_2 measurements. The CO_2 content of the flue gas causes a change in the thermal conductivity of the gas surrounding one thermistor, Fig. 9(A), thus unbalancing the bridge circuit and causing the meter to deflect an amount proportional to the percent carbon dioxide.

A similar circuit used for draft measurements is shown in Fig. 9 (B). The draft (vacuum) at the end of the sample hose causes room air to be drawn in through the pinhole, cooling one thermistor by the motion of the air and unbalancing the bridge. The meter used with this particular circuit reads 0.1 in. of water full scale.

Besides the applications already discussed, thermistors are used in the gain control system on long-distance telephone carrier systems, and to stabilize the oscillators in such systems. They are also used in telephone signalling systems to prevent false operation of relays caused by spurious signals. Volume limiting, compression, and expansion have also been accomplished with thermistors. Some military equipment uses thermistors to obtain a constant reference voltage for regulated d-c power supplies. A precise a-c voltage regulator has been built using a thermistor as the control element to regulate the *rms* value of a complex wave to a precise value without distorting the wave shape or introducing harmonics.

Thermistors with separate built-in electrical heaters are currently being used as in a voltage and frequency regulator for aircraft generators.

This material shows that thermistors are normally used because of their temperature sensitivity. However, there are many uses based on the negative coefficient that are not directly concerned with temperature measurement.

TECHNICAL NEWS

PLASTIC BEADS are poured into mold of toy boat, leaving plenty of room for expansion. When heat is applied . . .

. . . Polystyrene foams and fills mold with fluffy, snow-white plastic whose outside skin is tough enough to resist crushing

Plastic Beads Foam Into Polystyrene Products

A FOAM-TYPE PLASTIC that can be molded to any desired shape has been developed by the Research Department and Chemical Division of Koppers Co., Inc. The new material is produced as tiny hard beads of polystyrene, impregnated with a special foaming agent that reacts under heat like moisture in a kernel of popcorn.

According to Dr. G. F. D'Alelio, Vice President in charge of Koppers Research Department, Koppers Foam Plastic has better insulating properties than cork, glass fibers or mineral wool (its thermal conductivity: 0.214 BTU per hr per sq ft per deg F per in. at 19.9 F; and 0.267 at 120 F.).

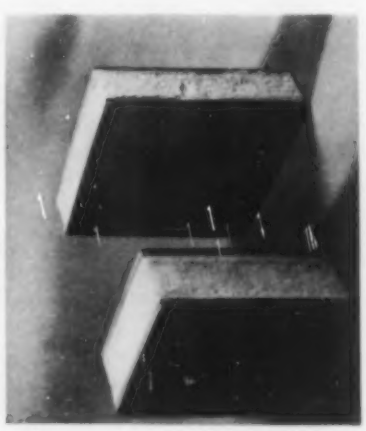
Said Dr. D'Alelio, "Insulating properties combined with moldability should make the new material valuable for uses such as refrigerator door liners that have to be shaped. Because of its lightness and buoyancy, it can be molded readily into many shapes."

Control of density of the finished product is accomplished by regulating the amount of material placed in any given mold. Density can range from a fluffy two pounds per cubic foot up to a dense 10 lb per cubic foot.

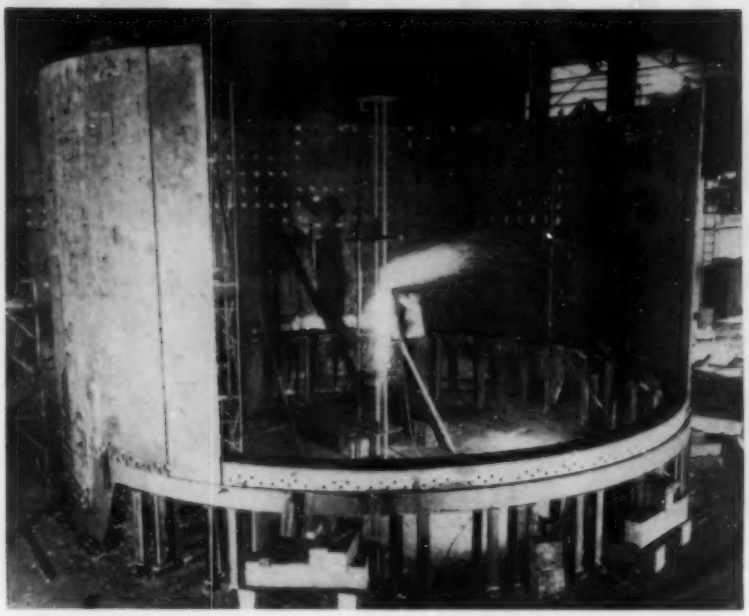
When the plastic beads are subjected to heat in the mold, they expand, crush together and adhere to each other. Formation in the mold creates a surface toughness which resists crushing of the expanded material. Tests indicate less than one-half of one percent water absorption by volume in immersion for one week.

LABORATORY TECHNICIAN weighs out the amount of plastic beads that will produce the expanded plastics in the right hand scale pan.

CLOSEUP OF BEADS after they have been expanded out of a mold. When molded under pressure they have a tough skin which gives them unusual strength.



SANDWICH CONSTRUCTION combines lightness and strength. Sandwiched between aluminum (above) and plywood (below), it adheres readily.



TUNNEL SHIELD that will drive the third Lincoln Tube under the Hudson River nears completion at American Locomotive's Schenectady plant. When finished, the device will measure over 31 ft in dia, weigh 240 tons. It is fabricated from structural steel and steel plates. Serving as the actual cutting edge, the shield is thrust through river muck by tremendous hydraulic pressure as the many tons of sediments, rocks and mud are driven ahead and removed from in front.

Air Force Starts Human Acceleration Tests

WHAT KIND OF EQUIPMENT is needed to enable air crews to survive bail-outs from jet airplanes traveling at supersonic speeds? Air Force volunteers at Holloman Air Development Center are preparing to ride the world's fastest land passenger vehicle to help answer that question. The data obtained may lead to a new concept of design for survival equipment.

The experiments are being conducted on a 3,500 ft railroad track at Holloman, using a 750 mph rocket-propelled sled. Subjects who ride the sled are strapped into a chair that rotates them head over heels, 180 times per minute, exposing them to the same air blast forces that would be experienced by a pilot suddenly ejected from a supersonic airplane. The human guinea pigs will travel faster than man has ever before moved on the ground.

Among the factors to be determined: thresholds of reasoning, consciousness and memory. ARDC scientists engaged in human factor experiments warn that a human with no protective equipment has little chance of surviving a supersonic bail-out.

Initial tests using dummies have been run at comparatively slow speeds. Now, the range is ready to conduct experiments with human subjects.

Test Equipment

Main portions of the test equipment are two sleds—a test sled and a propulsion vehicle. Twelve 4,500 lb thrust rockets mounted on the propulsion vehicle drive the test vehicle until it reaches the required speed. Then, the rocket sled is retarded while the test vehicle coasts free at high speeds during the brief test period.

Speeds of 750 mph on the ground at Holloman where the elevation is 4,092 ft above sea level simulate a bail-out from an open seat at 40,000 ft altitude and a speed of 1,800 mph.

When fully loaded with rockets, the propulsion vehicle weighs over 3,500 lb. It is 84 in. wide and 90 in. long. The test sled loaded with an average subject weighs about 2,000 lb. It is 84 in. wide and 150 in. long and is designed to withstand forces up to 100 G's with a 50 percent safety factor.

Forces generated by scooping water up at high speeds provide a predictable and highly effective braking force. The braking system consists of a trough 5 ft wide and 18 in. deep, extending the full length of the rail track. At the specified braking point, small plastic dams are inserted to inclose water for the desired braking distance. Metal scoops extend beneath both the propulsion vehicle and the sled to pick up water for braking. Because the scoops beneath the propulsion sled are longer than those on the test sled, the rocket carrier slows faster and permits the sled to travel ahead and stop individually.

Metal Powder Show

BECAUSE OF THE INCREASE in the use of powdered metals, the Metal Powder Association expects their tenth annual meeting and show to be the biggest in the Society's history. Meeting at Chicago's Drake Hotel, April 26, 27 and 28, MPA's sessions will cover powder metallurgy, the metal powder industry, and arts and sciences based on metal powders.

Technical meetings are divided into two parts: (1) a general session devoted to papers covering a variety of aspects of powder metallurgy, and (2) an Electric Core session consisting of a separate all-day meeting devoted to subjects in this field.

Both meeting and show are open to MPA members and non-members.

Spinning-Like Process Forms Tough Metals

A NEW METAL FORMING TECHNIQUE, called the Floturn process, may save time and money when working tough alloys. Announced by Lodge & Shipley Co., Cincinnati, the new process uses a hardened ground roller to apply pressure to a rotating metal blank, causing the metal to cold flow to the shape of a mandrel.

The process can start with a simple

flat blank, machined blank, machined forging, drawn cup, wrapped and welded cylinder or a centrifugal casting. The end product is a cone, cylinder, combination of the two or other complex shape made about an axis.

To date, the technique has been applied to shape a variety of tough materials associated with jet engine components.

However, Lodge & Shipley claim the process also works well with these metals: copper, aluminum, mild steels, 300 and 400 series stainless steels, Inconel, Inconel X, Monel, K-Monel, and Titanium TI-140-A.

With present equipment, it's possible to work blanks of the harder metals in thicknesses up to ⅞ in. With softer metals the thickness is increased to ½ inch.

Optical Gratings In Machine Tool Control

LONDON—National Physics Laboratory has been studying a technique that uses optical gratings to measure length precisely and to control automatic machine tools. Main objective of such equipment: to locate where the cutting tool or work is and relay this information back to the controlling unit.

The device uses two Merton-NPL gratings placed upon each other so that their rulings are inclined at a small angle. This produces dark lines or fringes which run at right angles to the rulings and resemble the "moire" effect of watered silk. When one of the gratings is kept at rest, and the other is moved slowly in the direction of the fringes, the fringes also move—but at a greatly magnified rate.

A photo cell and electronic counter determine the number that pass across the field of view.

By using gratings ruled with 10,000 grooves per in., NPL has been able to record movements in ten-thousandths of an inch. Currently, the laboratory and one British industrial firm are modifying a unit to control automatically a jig borer. When this work is completed, it will be possible for machining operations to be performed from instructions stored in a tape machine.

Thermocouple Identifies Metal

THERMOELECTRIC METAL COMPARATOR—a fast, accurate, non-destructive instrument for sorting metal parts with varying alloy content—has been developed by General Motors Research Laboratories. Operating on the principle of the thermocouple, the device also can detect chills in castings (which cause hardness differences) and can measure thickness of paint films and metallic plating.

The comparator's circuit is a loop of two different metals, but the part being tested forms one part of the loop. The instrument's two probe tips that touch the metal under test are the "hot" and "cold" junctions.

Since the temperature of the two junctions are constant, any change in metallic composition of the test part causes a voltage change that can be read on the instrument's meter. Because this voltage is so small, an amplifier is included in the circuit to make possible use of a quick response time indicator to increase sensitivity.

Several sets of probe tips are available in different alloys of steel and metals. In this way, the comparator can be adapted for any specific problem by selecting the right set of tips.

To use the instrument, an operator who needs no special skills merely touches the probes to a metal part, obtaining an instant reading that compares the part's composition with that of another part. When measuring the thickness of electrically non-conducting films—such as paints on metals—a thin sheet of copper and aluminum foil is placed over the paint film to complete the electrical circuit between the comparator's two probes.

To date, GM has used the instrument in a variety of jobs:

- Sorting a stock of mixed steel in which SAE 1112 and SAE 1117 were separated. Since these steels differ only by 0.05 percent in carbon content, it is difficult to differentiate between them rapidly by any other means.
- Preventing a mixup of metallic test bars used in inspection work.
- Separating two types of automotive valves, differing only slightly in chemical content.
- Separating a mixup of 12,000 clutch levers, some made of SAE 1010, and others made of SAE 1020.
- Detecting chills in castings.

THERMAL COMPARATOR quickly sorts metal parts when varying chemical composition or alloy content are the only distinguishable feature.

Ministry of Supply: Britain's Research Organization

Many technical men in the U.S. have been interested in the workings of Britain's most important research organization. So Product Engineering asked its London correspondent for a report on this agency. He cabled this reply.

LONDON—Every week the classified columns of The Times of London announce that Britain's largest scientific organization is looking for scientific and engineering talent to join thousands of other scientists and engineers at one of the 14 major Ministry of Supply research and development establishments in the U. K. or their branches at home and overseas. The work includes all of Britain's atomic energy program, most of Britain's researches into guided weapons, and most research into electronics, aerodynamics, and conventional weapons and munitions for the Royal Air Force, the British Army, and the Royal Navy.

As initiator and co-ordinator of much of Britain's scientific research, MoS can report considerable success. One reason: many of MoS' facilities are unique in Britain; the medium and small British private companies—the typical English firms—cannot or will not spend large sums to keep private research facilities modern. Since the war, joint research associations—financed in part by the British government's Department of Scientific and Industrial Research and in part by private industry—have encouraged private companies to become more research-conscious. But the Ministry of Supply, pressed by the need for defense research, has shown the biggest expansion. Then, too, in Great Britain no defense plant or research establishment is more than an hour's flight away from any other, so the possibilities for co-ordinated effort are limitless. And there is the ever-pressing incentive of severely limited funds.

Unification of the Services

Since a large part of MoS research is initiated by the armed forces, coordination between the service departments and MoS has come a long way. The R.A.F. particularly, the British Army, and—to a lesser extent—the Royal Navy work out their specifications for equipment in the laboratories of the MoS research establishments. (The Navy still maintains a few research facilities of its own.)

Top man is Minister of Supply Duncan Sandys, a junior minister since he does not hold a cabinet post. But the men who direct the day-to-day work of the various research establishments are evenly divided between civilian and military.

A career civil servant, S. S. C. Mitchell, is MoS Controller of Guided Weapons and Electronics. His deputy, in charge of electronics development, is a Royal Navy officer, Rear Admiral G. F. Burghard. Air Vice Marshall Sir John Baker, of the R.A.F., serves as Controller of Supplies (for Air); an Army man, General Sir Kenneth Crawford, is Controller of Supplies (munitions).

Britain's atomic energy program, an MoS responsibility, is headed by a former soldier, Lt. Gen. Sir Frederick Morgan (ret.). His top assistants are civilians: Sir John Cockcroft, director of the Atomic Energy Research establishment at Harwell, and scientist Sir William Penney, director of Britain's Atomic Weapons Research Establishments including the test center in Woomera, Australia.

Number one adviser to all these top administrators—except on atomic energy matters—is MoS chief scientist, O. H. Wansbrough-Jones. His job: to encourage pure scientific research to the maximum extent of available time and funds. His efforts are directed at "building scientific capital." The scientist who wants to pursue a line of research not leading to a prescribed target will apply to Wansbrough-Jones for assistance. Such projects are usually encouraged—sometimes as spare time work, often as full-time, government supported research. This policy—plus the accompanying concept of academic freedom—plays an important role in keeping personnel turnover low.

Industry's Role

MoS tries to bring private industry into the research picture whenever possible. Through research contracts, sometimes written to specifications drawn up between MoS and one of the services, sometimes to specs suggested

Major MoS Establishments

The Aeroplane and Armament Experimental Establishment
The Marine Aircraft Experimental Establishment
The National Gas Turbine Establishment
The Royal Aircraft Establishment
Atomic Energy Research Establishment
Atomic Weapons Research Establishment
Armament Design Establishment
Armament Research Establishment
Clothing & Equipment Physiological Research Establishment
Explosives Research and Development Establishment
Fighting Vehicles Research and Development Establishment
Military Engineering Experimental Establishment
Radar Research Establishment
Signals Research And Development Establishment

by industry itself, MoS does much to encourage private firms to build their own research teams.

In the aircraft industry particularly, industry teams do the lion's share of the work. MoS' Royal Aircraft Establishment (RAE) at Farborough is the largest center of its kind in the U. K. But there are at least a dozen airframe and engine companies with design teams largely kept alive by MoS research contracts. The doors at RAE are always open to these private designers for testing and consultation. So are the runways and test facilities at MoS Flight Testing Station, Boscombe Down.

Much equipment is, of course, developed entirely inside MoS establishments. But industry is never far away. MoS Signal Research & Development Establishment, for example, will develop equipment to army specs and then solicit bids from several companies to make it. MoS Radar Research Establishment recently evolved a method of packaging electronic tubes, and industry was invited to copy it.

The Ministry's attitude towards ownership of its own designs or those developed by industry under MoS research contracts is calculated to make U. S. manufacturers envious. Industry is free to exploit commercially any equipment developed under MoS research contracts on payment of a royalty after sale. MoS may have done most of the research, but the company can claim legal ownership of the design.

If the equipment is developed solely within MoS establishments provisions are made for industry to cash in. Largely as the result of Sir Frank Whittle's jet engine inventions, the government has set up a corporation, the National Research & Development Corp., which, among other things, is responsible for pushing out MoS inventions in this manner. The corporation holds the patents.

There are relatively more independent units in the British aircraft industry than in the U. S., and the competition for the limited government funds is razor sharp. It is not unusual for British airframe and engine builders to sink their own money into military research in order to get a jump on a competitor. One recent example: deHavilland Engine Co.'s Gyron jet engine—rated up around 15,000 lb thrust. The Gyron was developed as a "private venture"—the MoS didn't step in with a contract until the engine had passed its initial bench tests. There are a number of "private venture" military aircraft—research and otherwise—flying around Britain today that don't represent a penny in new government money.

Salary Ranges for MoS Scientific Personnel

Scientific Officer	$1,230 to	$2,000
Senior Scientific Officer	2,280	2,840
Principal Scientific Officer	3,000	4,075
Senior Principal Scientific Officer	4,410	5,145
Deputy Chief Scientific Officer	5,450	6,240
Assistant Experimental Officer	700	1,550
Experimental Officer	1,750	2,165
Senior Experimental Officer	2,520	3,010
Chief Experimental Officer	3,080	3,700

British technical societies offer another example of MoS-industry cooperation. It is common for officials at MoS research establishments to hold positions in relevant industry associations and professional scientific societies. In such capacities they are in a good position to see that information about their work gets to the people most interested.

Wanted: Qualified Manpower

Probably the toughest shortage for MoS administrators is manpower. Speaking for only one MoS establishment, but probably typical of many, S. S. C. Mitchell, MoS controller of Guided Weapons and Electronics, said recently: "It is technologists we lack. In research and science I think we are in a magnificent position, but on technology I think we are weak, particularly on production technology. We need something of the M.I.T. type of place in this country."

Almost all MoS establishments run technical schools on the side in an effort to make up for the deficiencies in the British educational system. Youngsters 15 to 18 years old are invited to join ministry apprentice schemes, which lead either to skilled trades or an engineering career. Every effort is made to encourage these apprentices to study at night schools and to compete for university scholarships.

The persistent U. S. myth that MoS gets all the best British scientific brains because it pays more than industry, is disproved by the facts. British industry often pays twice MoS salaries, especially for top-bracket scientists. And British industry in turn is constant prey to American and Canadian raiders who can offer salaries twice as high.

But available figures indicate that the drain of men from MoS establishments to industry or abroad is nowhere as serious as the general shortage of technologists. Last year, for example, MoS Radar Research Establishment reported a loss only two percent of its personnel to industry.

The fact that in many cases MoS facilities have no counterpart in industry is another reason for low turnovers.

Scientists are recruited into the ministry in two ways:

(1) Permanent staff—those eligible for a pension—are engaged by the Civil Service Commission; (2) Unestablished staff—not eligible for pensions—are engaged by the Ministry.

Scientific posts within the Civil Service fall into two broad categories:

(1) The class of Scientific Officer, open to holders of scientific degrees with first or second class honors. (2) The class of Experimental Officer, open to both holders of degrees and to holders of Britain's Higher National Certificate of Education.

With the capital costs of research mounting even higher, the chances are all in favor of MoS expanding in the years to come. Or at least the British government's stake in research will be greater, for MoS research is very largely confined to defense.

Aircraft Industry Readies New Designs

TWO WEST COAST AIRCRAFT manufacturers took the wraps off new designs last month. The new ships contain a flock of engineering innovations.

The big news from Renton (Wash.) was the lifting of the secrecy curtain hiding America's first jet transport. At the Boeing Airplane Company, the four jet engine prototype is nearing completion, and observers expect preliminary flight tests this summer.

Representing an investment of $15,000,000 the big transport is 128 ft. long, its wings measure 130 ft from tip to tip and it will weigh 95 tons when fully loaded. Powered by Pratt and Whitney, 10,000 lb thrust, turbojet engines, the ship will cruise at about 550 mph. That means airlines will fly non-stop from New York to Los Angeles in less than five hours, New York to London in less than seven.

As a commercial airliner, the new ship will carry from 80 to 150 passengers. Or, it can be outfitted to serve as a multi-purpose tanker transport for the Armed Forces.

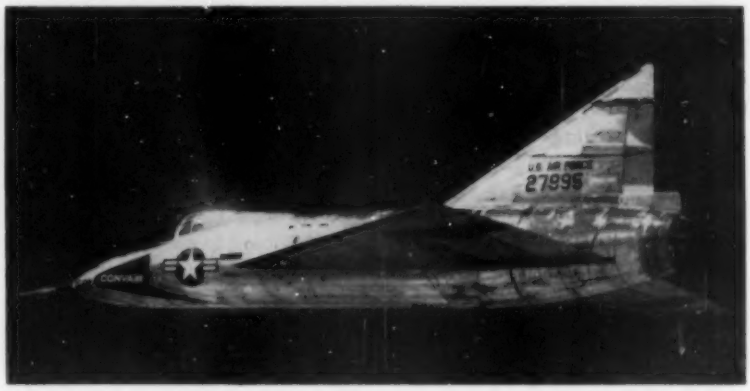
Meanwhile, in California, Consolidated Vultee Aircraft is flight testing two new ships: one a delta-winged, supersonic fighter; the other, the first U. S. turboprop-powered seaplane.

The Navy's new flying boat, the R3Y Tradewind, is powered by four Allison T-40 turboprop engines, each with an output of 5,500 hp.

However, power is not the only unique feature of the R3Y. It is also the first seaplane to be equipped with rearward facing passenger seats. Instead of having a hydraulic system to operate components, the Tradewind boasts a smaller, lighter pneumatic system. And, it is the first flying boat with high-altitude pressurization (up to 35,000 ft) and air conditioning.

Convair's F-102, a delta-wing all-weather interceptor, is undergoing tests again after being damaged in an emergency landing last November.

JET TRANSPORT almost completed in Boeing shops may start a new era in American aircraft design. The 85 to 105 passenger capacity plane will make the trip from New York to Los Angeles in under five hours.



CONVAIR F-102, delta-winged interceptor flashes through the sky in tests over Air Force desert bases. Observers expect this to be the first U. S. "true" supersonic aircraft, meaning it can crash the sound barrier while flying in the level.

TURBOPROP FLYING BOAT takes off from San Diego Bay during first flight test. The 80 ton seaplane, the first powered this way, is 142 ft long, with a 145 ft wing span.

ASTE Membership Climbs

MEMBERSHIP in the American Society of Tool Engineers reached a new peak in 1953. As of December 31, there were 23,989 tool men enrolled with chapters throughout the country, an increase of 4,015 over 1952's peak.

ASTE's executive secretary, Harry E. Conrad, reported that the society organized ten new chapters during 1953, raising the number of affiliated groups to 112.

New Alloy for Stainless Applications

WASHINGTON — While studying the physical characteristics of a non-critical, "soft," aluminum-iron, magnetic material, metallurgists at the Naval Ordnance Laboratory unexpectedly turned up a new high-temperature alloy capable of replacing stainless steel in many applications. The surprise development: the addition of five percent of either vanadium or molybdenum, to the aluminum (16 percent) and iron (84 percent), produced unique features: high electrical resistivity, corrosion resistance, reasonably high tensile strength, improved ductility and heat resistance.

NOL has named the new material Thermenol. It is 20 to 25 percent lighter than stainless steel, and when heated to 1,300 C, its weight losses are low.

Because of the high aluminum content, the alloy has good resistance to corrosion and oxidation. A coating of aluminum-oxide forms on the metal for protection.

One reason why Thermenol looks so promising to Navy engineers is that it does not rely on large quantities of such hard-to-get alloying agents as cobalt, nickel and chromium. Its use, instead of stainless steel for jet engine parts, would make large quantities of the critical materials available for special applications that need them more. And, at the same time, make possible a weight reduction.

According to preliminary creep-to-rupture tests conducted by the Lewis Flight Propulsion Laboratory of the NACA, at 1,200 F, Thermenol is "better than some forms of stainless steel being widely used in the aircraft industry today." Additional tests are still in progress.

In the long run, NOL thinks that the material should be relatively inexpensive because the basic ingredients —aluminum and iron—are cheap and plentiful. Also, Thermenol is easily worked. Some possible applications: substituting for stainless steel in jet engine tail cones and exhaust systems, chemical processing equipment subjected to corrosion, and because of its high electrical resistivity, such items as heater elements for toasters, low temperature industrial furnaces and electrical appliances.

But metallurgists were quick to point out that Thermenol is not competitive with the so-called "super alloys" or wonder metals. For instance, titanium is much lighter than the new alloy (comparing specific gravities: titanium, 4.5; Thermenol, 6.5; and stainless steel, 8.0). And special purpose alloys like Inconel last over twice as long at high temperature, high stress conditions.

So far, no company has signed up to produce the new alloy commercially.

Heavy Duty Transmission Combines Two-in-One

COMBINING TWO AUTOMATIC transmissions in one unit, GMC Truck and Coach Div., General Motors Corp. has developed an automatic transmission for heavy duty trucks. GMC plans to introduce the unit in 150 hp trucks; later, the units will be available in conjunction with gasoline and diesel power plants in the 175 to 225 hp ranges.

The "Twin-Hydra-Matic" consists of an upper and lower unit mounted one over the other and governed to shift alternately with each other, through seven forward speeds and one reverse. Both units are geared together at the rear, driving a single output shaft connecting with a three-speed reduction unit.

This combination of a Hydra-Matic and reduction unit will give automatically the gear shifting that is required under the varying conditions throughout the three separate ranges —creeper, low, and direct.

News Briefs

• Ford Motor company has joined the research team of Detroit Edison Company and Dow Chemical Company, studying the problem of civilian atomic power generation. Three Ford engineers have been cleared to conduct special studies. Their immediate objective: to develop new alloys and metals that will withstand the tremendous heat released by atomic reactions.

• Thirty educators met at the Carnegie Institute of Technology last month to discuss additions to engineering curricula. Main purpose of the group was to establish an agenda for a larger meeting to be held at the school in June. One question that evoked a lot of discussion: should solid state science (the basis of transistors) be introduced into the undergraduate program of U. S. engineering colleges?

• Ohio State University plans an Annual Conference for Engineers. The first is scheduled for May 7, 1954. Big portion of the program will include reports from various OSU departments on current research in aeronautical engineering, ceramic engineering, electrical engineering, metallurgy, mechanical engineering, welding engineering and other technical fields.

• Radio Corporation of America has shipped the first Color TV cameras from its commercial production line. Recipients: broadcasters NBS and CBS.

• New York Subway has taken steps to build a fully automatic underground railroad. Union Switch and Signal Division of Westinghouse Air Brake will install an electronic watch dog system on the Flushing line. In operation, subway trains will identify themselves as they pass wayside check points, setting up switch and signal operations that show a central operator the train's location and identity.

• West German exports of optics and precision tools in 1953 totaled 426 million marks ($108 million), up five percent over 1952. Among the recipients of goods: West European countries, 41 percent; U. S. 37.6 percent; down slightly for the first time since the end of the war.

a helpful guide to relay and stepping switch selection

1. when first cost is important . . .

You can hold down costs with this "all-purpose" relay. Meets Automatic Electric's high quality standards—gives long, dependable service. For dc operation only.

Class "A" Relay

2. for outstanding endurance, dependability . . .

When extremes in long service life and reliable operation are demanded, this relay meets requirements. Life often exceeds 400 million operations! For ac or dc operation.

Class "B" Relay

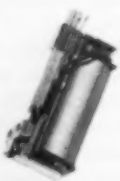
3. when size limits relay selection . . .

This compact relay combines unusual dependability and surprisingly long service-life in a space about half the size of the average relay of equal rating. For dc operation only.

Class "C" Relay

4. for alternating current only . . .

Here's a relay for use where ac is the only power source—where operate or release time delays are not a factor—where low power consumption is a *must*. For ac operation only.



Class "F" Relay

5. for exacting miniature applications . . .

For aircraft use where resistance to shock and vibration must be met by a small, light relay. Rugged, reliable. For dc operation only.

Class "S" Relay

6. for maximum timing with reduced size . . .

You can order this miniature relay with specific time-delays, plus many other special features. For ac or dc operation. Time-delay is for dc operation only.

Class "Z" Relay

Rotary stepping switch features . . .

For complicated space and weight problems, specify Type 44. By proper wiper arrangement, this sturdy switch can provide 10-, 20-, or 30-point operation. For up to 110 V. dc, or built-in rectifier for 115 V.-60 cycles.

Use Type 45 for greater capacity. Available with 2 to 10 (or more) 25-point bank levels. Can be used with wipers arranged independently for 25-point operation; or in staggered pairs for 50-point operation. For up to 110 V. dc, or for 115 V. ac.

send for:
Relay Circular 1702.
Stepping Switch Circular 1698.

7. to combine relay and stepping switch functions . . .

Here's a shock-resistant, cam-type relay for cam-switching, alternate on-off operations. Use as a "stepper." *You* specify programming. For dc, or 115 V.-60 cycles ac rectifier operation.

Series "OCS" Relay

8. special features available . . .

For applications where atmospheric conditions will affect relay performance, all Automatic Electric relays are available in hermetically-sealed enclosures. Special plug-mountings may also be specified for Class A, B, F, S and Z Relays.

Class "S" Relay

Automatic Electric's high standards of quality, workmanship and engineering offer you the finest relays and stepping switches money can buy, in a complete selection to fit your needs. *Write today for complete information. Automatic Electric Sales Corporation, 1033 West Van Buren Street, Chicago 7, Illinois.*

RELAYS SWITCHES

PRODUCTS OF THE INDUSTRIAL DEPARTMENT OF

AUTOMATIC ELECTRIC

CHICAGO

Stress Chart for Thick Cylinders

H. M. DURHAM

WHEN THE RATIO of the outer radius to the inner radius exceeds 1.14 to 1, a cylinder is usually classified as "thick." The distribution of stresses is nonuniform radially and a maximum at the inner radius. This stress variation is verified by mathematical anlysis as well as actual tests. To compute the stress values at the inner wall for different end conditions and materials several formulas are in use, each identified by its author. The chart, Fig. 1, is a ready reference for four such formulas to be used for thick cylinders having only internal pressure.

As the maximum stress (i.e., at the inner wall) is

Comparison of Formulas

AUTHOR	EQUATION	ASSUMPTIONS
(1) Lamé	$S_t = a + \frac{b}{r^2} = p\left[\frac{1+R^2}{R^2-1}\right] = p\left[\frac{r_o^2+r_i^2}{r_o^2-r_i^2}\right]$	Brittle Materials, Closed Ends
(2) Barlow	$S_t = \frac{PD}{2t} = P\left(\frac{r_o}{t}\right) = p\left(\frac{R}{R-1}\right)$	Open Ends
(3) Clavarino	$S_t = (1-2m)\,a + \frac{(1+m)}{r_i^2}\,b = \left[\frac{0.4}{R^2-1} + \frac{1.3R^2}{R^2-1}\right] = p\left[\frac{0.4+1.3R^2}{R^2-1}\right]$	Ductile Material, Closed Ends
(4) Birnie	$S_t = (1-m)\,a + (1+m)\,\frac{b}{r_i^2} = p\left[\frac{0.7}{R^2-1} + \frac{1.3R^2}{R^2-1}\right] = p\left[\frac{0.7+1.3R^2}{R^2-1}\right]$	Ductile Material, Open Ends

where

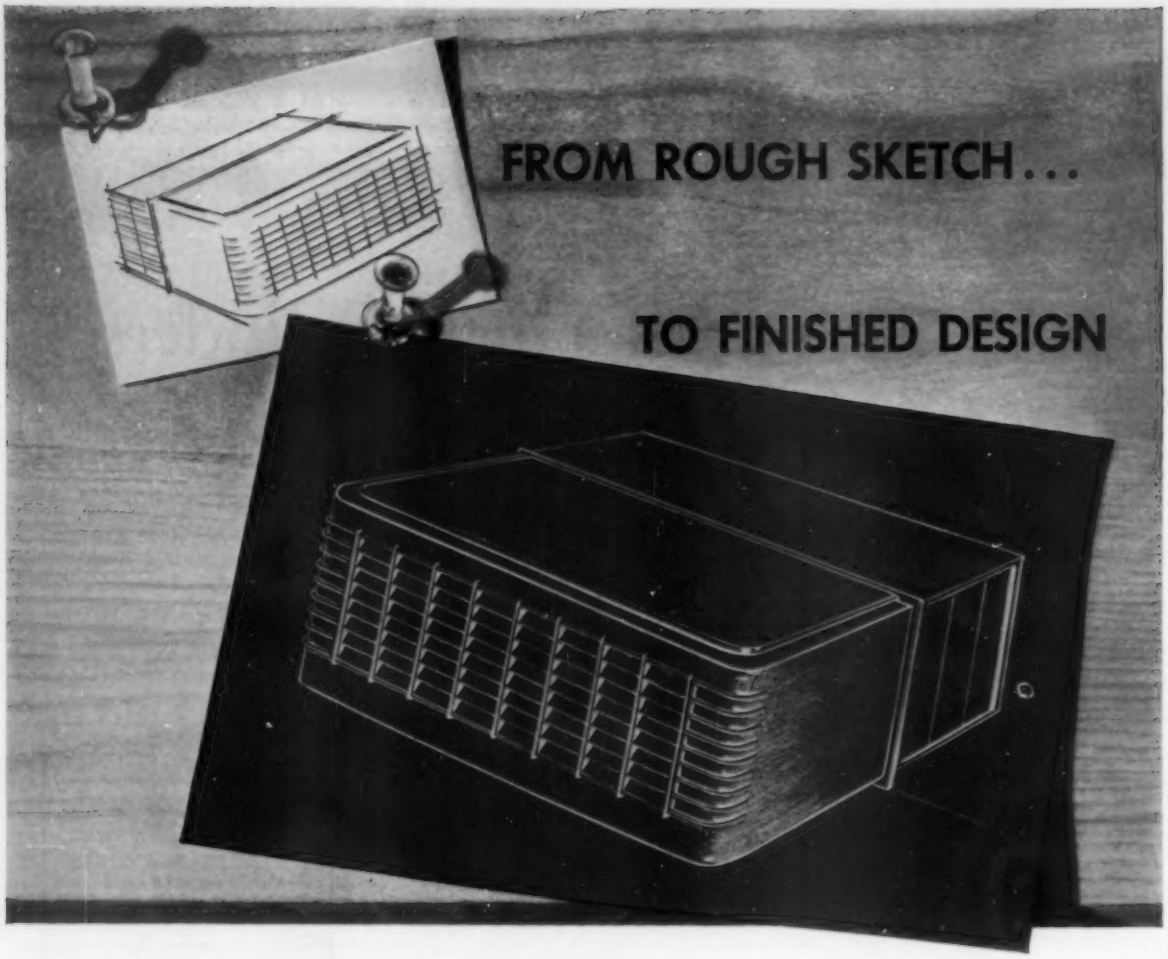
r_o = outside radius, in.
r_i = inside radius, in.
D = outside dia, in.
S_t = working stress, tension at inner radius, psi.
p = working pressure, psi.
m = Poisson's ratio (0.3 for steel)
t = wall thickness, $r_o - r_i$, in.

$$R = \frac{r_o}{r_i}$$

$$a = p\left(\frac{r_i^2}{r_o^2 - r_i^2}\right)$$

$$b = p\left(\frac{r_i^2 r_o^2}{r_o^2 - r_i^2}\right)$$

(continued on page 215)



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Stress Chart for Thick Cylinders (continued)

the usual design criterion, the values of the stresses at the other radii are of little consequence. The selection of any one formula depends upon such considerations as whether ends of the cylinder are open or closed and whether the cylinder material is ductile or brittle.

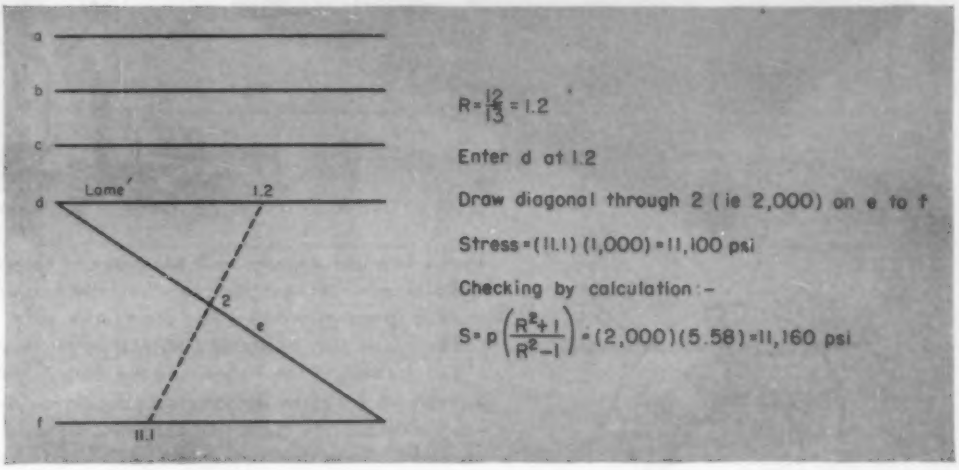
The Barlow Formula for thick cylinders is given here for purposes of comparison, but the stress values obtained through its use are undoubtedly high.

In general, Fig. 1 can be used in two ways:

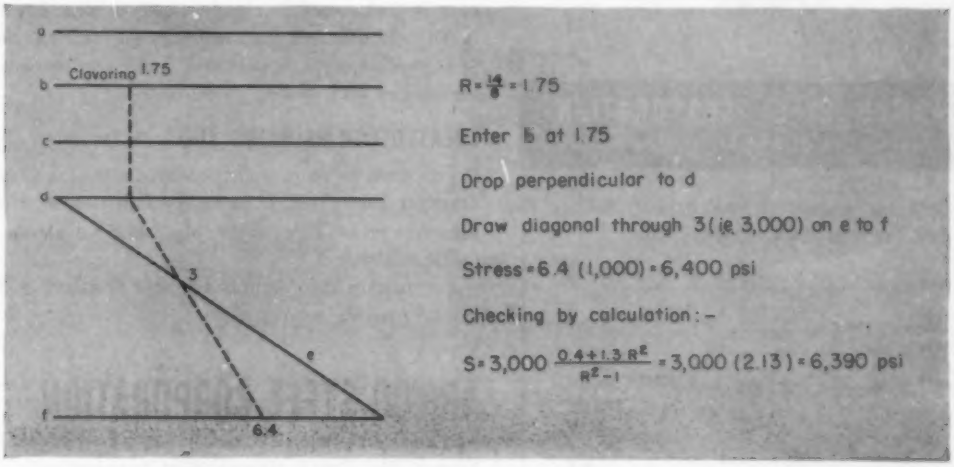
1. Checking existing designs; start at top scale and work downward.

2. New designs; working pressure and stress given. Start at lower scale and work upwards.

EXAMPLE 1: A cylinder having 10 in. ID and 12 in. OD is subjected to a working pressure of 2,000 psi. The material is brittle. Find the stress at the inner wall. Using the Lamé Equation with Scales *d e f*.



EXAMPLE 2: A closed end cylinder has a bore of 8 in. and an OD of 14 in. The working pressure is 3,000 psi. The material is ductile. Thus, the stress at the inner wall is found by Clavarino's equation.



(continued on page 217)

Designer gets deep draw with this SPECIAL ZINC-COATED STEEL

Here's how one designer took advantage of the deep-drawing qualities of Armco ZINCGRIP Steel. He eliminated finishing costs by specifying this special zinc-coated steel for a tackle box.

The box is *fully protected from rust* by the special zinc coating.

The drawing of box bottom and top, both 3 inches deep, would be a tough job for many uncoated drawing sheets. But Armco ZINCGRIP has the ductility to make both parts in 2 draws each. Besides, there's no flaking of the zinc coating even at the expanded and beaded rims, because the coating on ZINCGRIP stretches with the steel base.

MADE BY PATENTED PROCESS

Don't confuse Armco ZINCGRIP with ordinary galvanized steel. ZINCGRIP is steel coated in a molten bath of zinc, but the patented process is radically different from ordinary galvanizing. The result—ZINCGRIP—a product with remarkable coating adherence combined with a normalized deep-drawing steel base.

TREATED FOR PAINTING TOO

If you want to paint your products after fabrication, specify Armco ZINCGRIP PAINTGRIP. It has a specially-treated surface that takes and preserves paint. This paint-holding film withstands forming and drawing operations.

For further information on these cost-saving sheet steels, just fill in and mail the coupon.

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2964 Curtis Street, Middletown, Ohio

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Stress Chart for Thick Cylinders (continued)

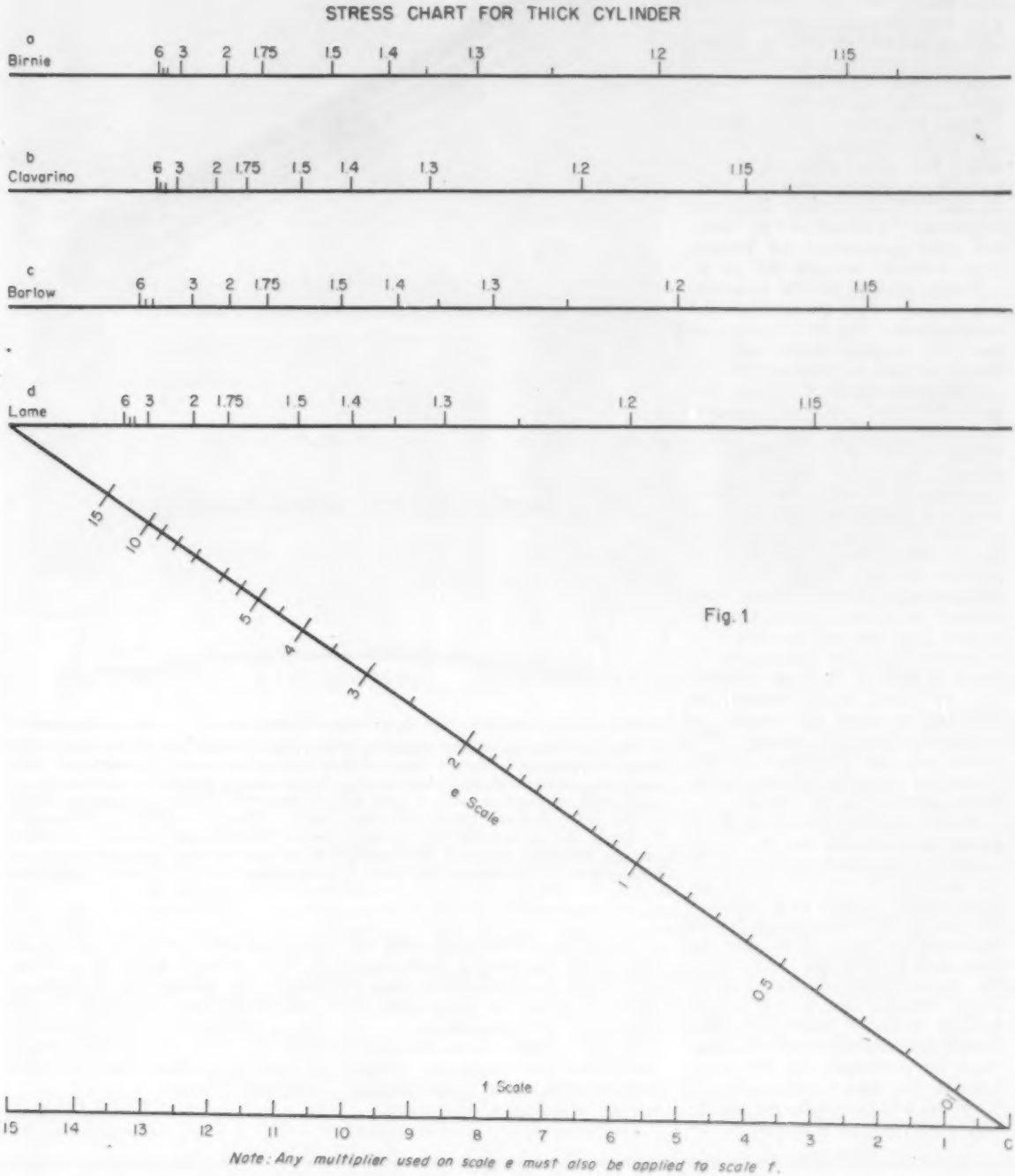


Fig. 1

Note: Any multiplier used on scale e must also be applied to scale f.

High Pressure Aircraft Hydraulic Accumulator

Of both single and double-shell construction, cylindrical type hydraulic accumulators for aircraft use, may be used with installations having pressures up to 3,000 psi. The units meet all requirements of MIL-A-5498, including gunfire and low temperature pre-charge leakage test.

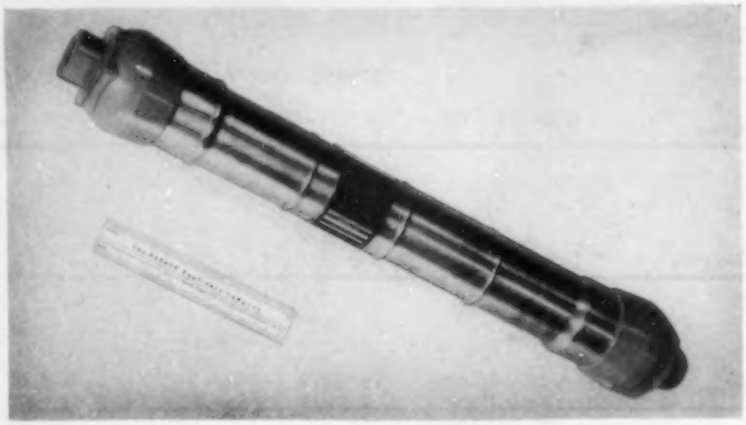
Presently, the accumulators are available in sizes ranging from 12¼ in. overall, 2¼ in. cylinder and 8$\frac{13}{16}$ in. stroke to 33$\frac{3}{8}$ in. overall, 4½ in. cylinder and 27$\frac{7}{8}$ in. stroke. Respective weights are 3.8 lb and 29.5 lb. Nominal total accumulator oil volumes range from 25 through 400 cu in.

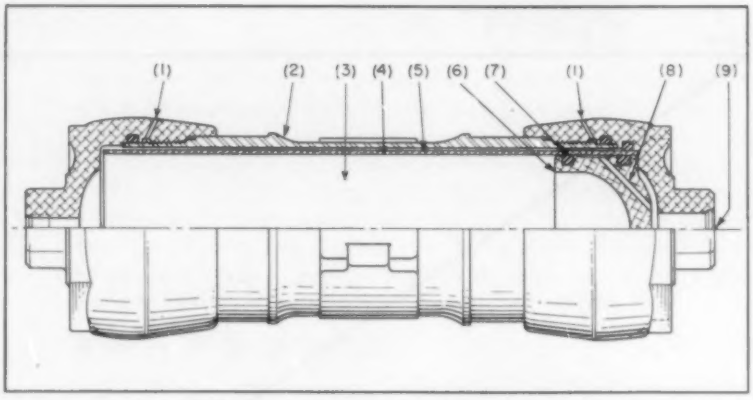
Design features of the accumulators include: (1) pressure-balanced inner cylinder; (2) free-floating piston; (3) warning vents; and (4) forged end caps with internal threads.

The pressure-balanced cylinder, distinct with the double-shell models, makes possible long seal life, thin-walled cylinders and safe reaction to gunfire. The pressure balancing is accomplished by providing an air space between the outer shell and the inner cylinder. The air space is connected to the air side of the cylinder. The air pressure can thus be applied equally on both sides of the cylinder wall. Normal air pressure in the chamber is about ⅓ the hydraulic pressure.

Pressure balancing enables the cylinder to maintain the same diameter over its entire length without the breathing or distortion normally accompanying pressure changes. The O-ring seals, are not required to compensate for changing diameters as the piston moves along the cylinder.

Should explosive shocks such as gunfire occur in the area of the accumulator, the compressible air cushion between the outer shell and the inner cylinder reduces peak pressures. The double-shell construction permits the immediate release of air when the outer shell is punctured. This reduces the forces behind the piston which would otherwise tend to eject a high-pressure stream of inflammable fluid. Should only the outer shell be punctured, air is released and the piston bottoms. The fluid is still retained by the piston and inner cylinder, and the system will continue to operate.





1. Vent for relieving of any remaining pressure if assembly should be attempted in event of incomplete release of air and fluid pressure at ports; 2. Outer shell, alloy steel tube, cadmium plate; 3. Air chamber. Normal charge pressure is 1,000 psi or 1/3 of working hydraulic pressure of 3,000 psi.; 4. Inner shell. Thin wall, seamless tubing; 5. Air space between inner and outer shell; 6. Piston, nonferrous, lightweight; 7. O-ring, acts as seal between air and hydraulic fluid during operation; 8. Drilled passages to permit hydraulic fluid pressure to act upon O-ring; also to minimize air impregnation of O-ring at 3,000 psi; 9, Outlet boss for 1/2 OD tube connection.

The air space between the inner and outer shell also gives a much larger surface for heat dissipation than is found in either the single-shell or diaphragm type accumulators.

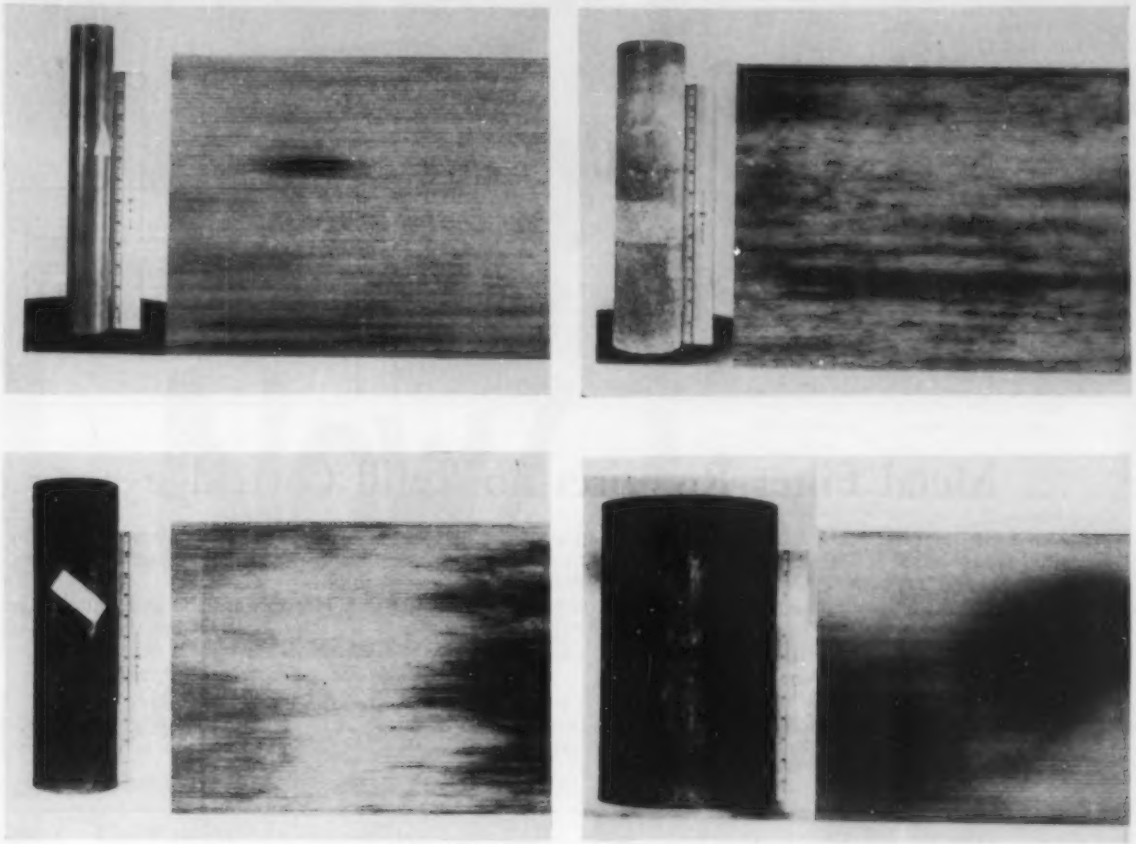
The accumulator is free-floating in that it does not contact the cylinder wall, but rides, rather, on two O-rings, one on each end of the piston.

Drilled passages in the accumulator end caps serve to warn of existing air or fluid pressure within the accumulator. The passages are so arranged (see illustration) that when an end cap is partially removed, either air or fluid will escape through the passages of internal pressures have not been completely relieved.

Parker Aircraft Co., 5827 W. Century Blvd., Los Angeles 45, Calif.

MATERIALS - PARTS

SPECIFIED BY PRODUCT ENGINEERS



Recorded, Ultrasonic, Non-destructive Test Data

New equipment for the ultrasonic, non-destructive testing of non-metallic solids incorporate ultrasonic absorption and automatic scanning techniques, and will produce high contrast records of simulated flaws, or mechanical defects which could not be detected in X-ray photographs.

In this new system a pair of barium titanate transducers are arranged to transmit and receive acoustic energy (continuous wave transmission at 383 kc-sec) along radii of the cylindrical test sample which is revolved about its longitudinal axis at 100 rpm. The transducers simultaneously transverse the length of the cylinder at a rate of approximately 0.1 in. per revolution of the cylinder, producing a helical scan the full length of the sample. This entire assembly is submerged in water for good acoustic coupling. The scanning mechanism is coupled through gears to a cylindrical recording drum having the same angular velocity as the test sample.

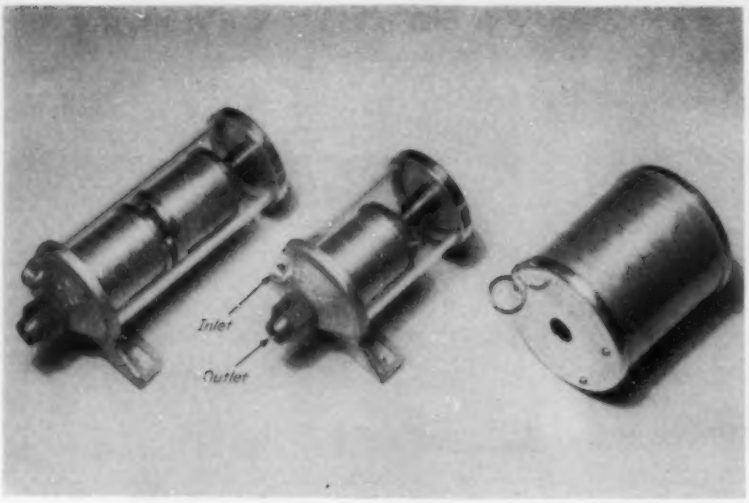
The output from the receiver transducer is fed through electronic circuitry to a tungsten stylus held in contact with electro-sensitive paper mounted on the recording drum. As in facsimile recording, the stylus transverses the length of the rotating drum, leaving a trace whose intensity (dot size) corresponds to the level at the receiver.

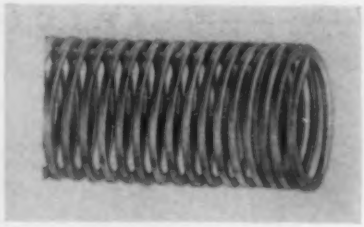
The resulting record, or acoustigraph, may be interpreted in the same manner as a positive radiograph which might be obtained by passing an X-ray source along the center perforation of a stationary cylinder wrapped with photographic film. Dark areas in both types of records represent regions of decreased transmission through the material. In the present equipment, a sample 14 in. long is represented by 3 in. on the record, a full revolution by 9 inches.

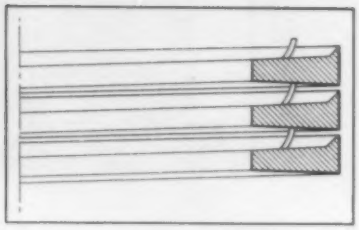
Top left, an acoustigraph of a formic cylinder. Top right, a concrete cylinder and its acoustigraph showing narrow horizontal bands due to layers of sand. Lower left, recording of a hard rubber cylinder formed by vulcanizing ½ in. sheet stock. Lower right, graph of an extruded graphite cylinder.

Reed Research, Inc., 1048 *Potomac St., N.W., Washington, D. C.*

CONTINUED ON PAGE 220







Metal Filter Requires no Refill Cartridge

Based on a filtering principle which the manufacturers claim is different from other types now available, a new all metal filter for oil lubricating and hydraulic systems does not contain any refill cartridge of fibrous material, cotton, felt or other material. Compact and efficient in operating, it is designed to permit filtering operations up to 1/200th of one millimeter.

Features are: an assured continuous filtering and flow; a filtering principle that operates indefinitely and makes it possible for the oil to retain all of its lubricating qualities; easy installation and maintenance on all internal combustion engines.

For cleaning, it is not necessary to disconnect either the inlet or outlet. Just unscrew the nut located at the bottom of the container, remove the filter element and clean both in gasoline.

Various sizes and arrangements of the filters are shown in the illustration above, left with the filtering element and principle of operation at right.

The Java Import Co.,
1 Wall St., New York 5, N. Y.

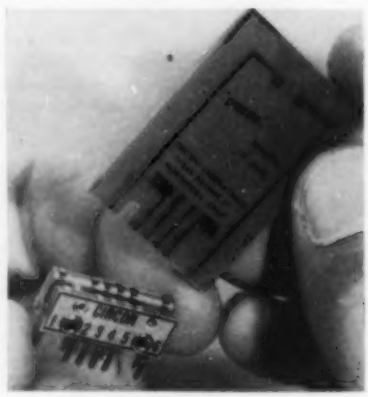
Simplified Connectors for Printed Circuits

This new series of miniature and sub-miniature connectors consists of sixteen models in each of the miniature and sub-miniature series in basic modules of two, four, six and twelve contacts at rated maximum loads of one and two amperes per contact. Offering better contact, performance and longer life, they permit side-by-side and end-to-end mounting of the desired combinations, and are said to be particularly adaptable to transistor circuitry. Channel design of the female connectors are open end to accommodate the straight edge of any size printed circuit without special shapes or fabrication required. Another advantage of the connecting units are that they will connect independently to both sides of a circuit. They are produced in three gages to accommodate $\frac{1}{32}$, $\frac{3}{64}$ and $\frac{1}{16}$ in. printed circuits.

The two and six contact female modules serve printed circuits requiring external connections to both sides. Height and thickness dimensions are the same on all modules within each series.

Ribbon female contacts of gold plated nickel silver are used, with each contact backed by a supported resilient compressible elastomer.

Terminals on the sub-miniature series are $\frac{3}{64}$ in. wide and are shaped to form a solder well. On the miniature series, terminals are $\frac{5}{64}$ in. wide. The miniature connectors are rated at 500 v d-c at sea level. With the mounting sleeves insulated, this rating can be doubled between the end and adjacent contacts. The sub-miniature connectors are rated at 300 v d-c.



Circon Component Co.,
17544 Raymer St.,
Northridge, Calif.

CONTINUED ON PAGE 222

Now!

HI-PRECISION GEAR BOX

RATIOS FROM 20:1 TO 3125:1

A new miracle in engineering — the LINK *Hi-Precision* Gear Box — is ready now for use in servo-mechanisms, computers and many other instruments that demand exceptional performance and design simplicity.

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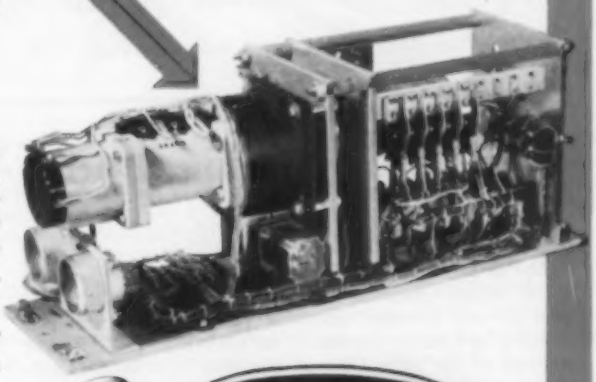
ADVANCED PERFORMANCE WITH THESE OUTSTANDING LINK FEATURES

1. **Virtually Friction-free** — Less than .01 inch ounces of frictional torque at the input to the gear box.
2. **Practically Backlash-proof** — Repeated tests find less than 0.27° on a gear box of 500:1 ratio.
3. **Low Inertia** — Aluminum gears, molecularly lubricated for a lifetime, help keep inertia down to less than 4.5 gram cm^2 on a 500:1 gear box.
4. **Long Life** — Continuous performance tests of a 150:1 gear box for more than 1800 hours under 90 inch ounces of load at 3000 rpm assures dependable service.
5. **High Torque** — Rated at 120 inch ounces off the slow turning shaft.
6. **Overall Dimensions** — 3½" x 3½" x 2-7/32".



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Manufacturers of the world-famous Link Trainers, servo-mechanisms, servo-amplifiers, graphic recorders, fractional h.p. wide range variable speed drives, spur gear differentials, friction and overdrive clutches, index dials, phase angle meters, ratio voltmeters, precision potentiometers and other special electronic devices.

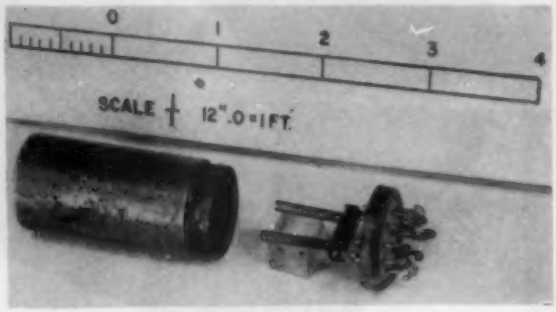
Analog Computers Based On Heat Transfer

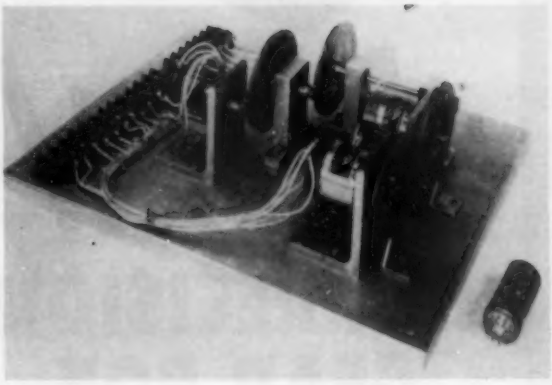
There are no wheels, shafts, rotors, slides, or cams in this new subminiature analog computer component which does its calculations by the interchange of heat. It adds, subtracts, multiplies, divides, integrates and performs basic operations of vector algebra and vector calculus. And, according to the manufacturer, in problems of multiplication, it replaces five times its weight and volume in precision instrumentation heretofore required.

This class of analog computers essentially makes use of a transducer in which an incoming electrical signal is dissipated into heat. The temperature differential that is created is picked up by a pair of temperature sensitive conductors mounted in a Wheatstone bridge. The output of the transducer is a direct function of the amount of unbalance caused in the Wheatstone bridge; it is also proportional to a reference signal to the bridge to detect the unbalance.

Of small size, lightweight, and plug-in replaceability, it has many advantages when used in aviation equipment. Possibilities here are navigational computers, bomb sights, true speed indicators, angle of attack indicators and the like. A variety of other applications also has been worked out in the servo and instrument field. Some are: quadrature and harmonic rejectors; modulators and demodulators; lead networks; in phase and quadrature signal separators and precision phase shifters.

The case of the subminiature (approximately 3 cu. in.) component is removed in the scaled view, above, right. Below it is shown (far right) with the geared assembly (a basic computer component assembly) which it replaces.





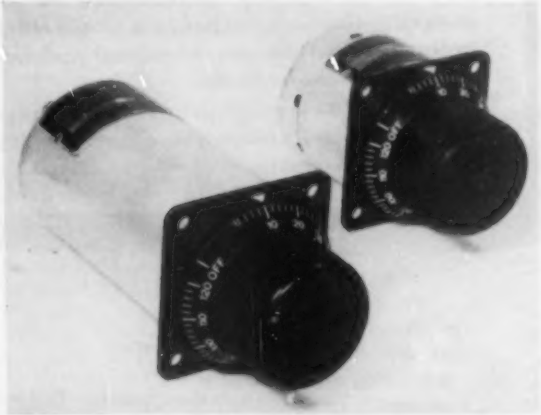
Arma Corp., Roosevelt Field, Garden City, N. Y.

Sequence Timing Under Varying Supply Voltages

The Intervalometers designated B-9A and B-10A, one of which is shown on the left in the illustration, are designed to furnish a 28 volt d-c, 3 amp, inductive pulse of 0.250 second duration at regular time intervals. The time interval between successive pulses may be changed instantly by turning the dial to the interval desired. Repeat accuracy of the pulse interval is within ±10 milliseconds over a supply voltage range of 24 to 29 volts d-c. Provision is made to start and stop the Intervalometer from a remote position. Each model has two interchangeable time interval scales, giving in all, four ranges to 12, 24, 60 and 120 seconds in 0.1, 0.2, 0.5, and 1 second increments respectively.

An auxiliary instrument, the Count Limiter, designated CN-1A1, shown on the right, may be used with the Intervalometer as a pulse counter and limiter for stopping the intervalometer at the desired number of pulses from 1 to 120 as set on its dial. Two count limiters may be connected together to provide control up to 14,400 pulses. Any number of intervalometers and limiters may be interconnected to give an infinite variety of pre-set pulse programs.

The intervalometer was developed for a sequence timing device to function accurately under varying supply voltages. The instrument has applications in aircraft fire control, navigation, aerial camera control, telemetering and missile control systems. Both units panel mount into a 2¼ in. hole. The intervalometer weighs 1.6 lb. and the limiter 14 ounces.

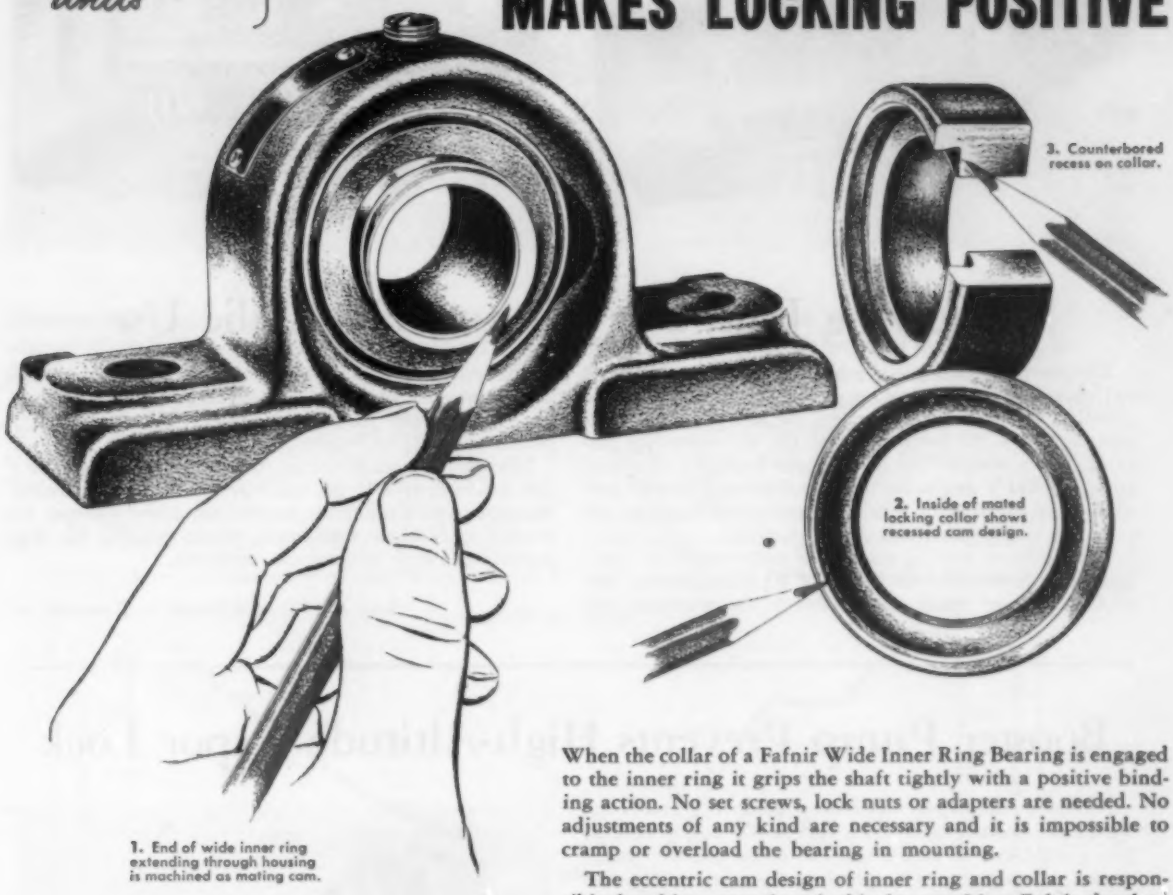


Abrams Instrument Corp., 606 E. Shiawassee St., Lansing 1, Mich.

CONTINUED ON PAGE 224

preference points on power transmission units

ECCENTRIC CAM DESIGN
of Inner ring and collar
MAKES LOCKING POSITIVE


3. Counterbored recess on collar.
2. Inside of mated locking collar shows recessed cam design.
1. End of wide inner ring extending through housing is machined as mating cam.

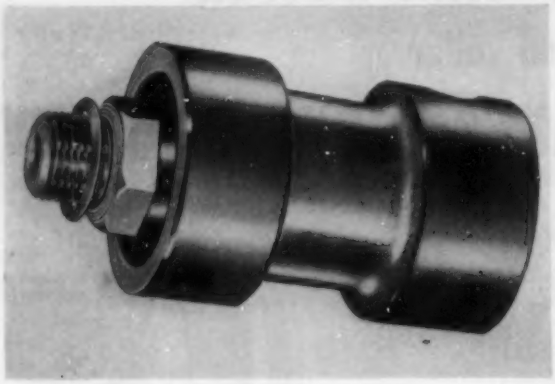
When the collar of a Fafnir Wide Inner Ring Bearing is engaged to the inner ring it grips the shaft tightly with a positive binding action. No set screws, lock nuts or adapters are needed. No adjustments of any kind are necessary and it is impossible to cramp or overload the bearing in mounting.

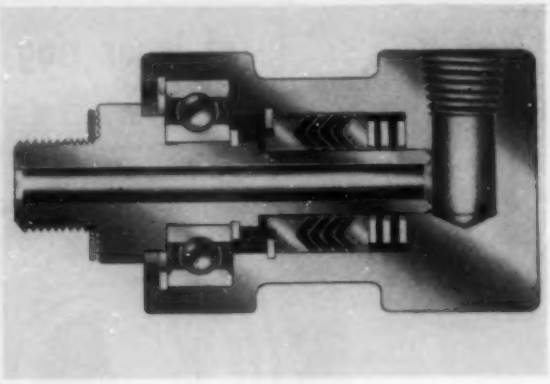
The eccentric cam design of inner ring and collar is responsible for this extremely valuable feature. It's a Fafnir development . . . tried and proven over the years. Shaft scoring is no longer a problem . . . and shaft slippage is out. The Self-Locking Collar transmits all thrust loads to the bearing.

For straight shaft mounting, the Fafnir Wide Inner Ring Bearing with Self-Locking Collar continues to rate "tops" as a feature of power transmission units. Every day it makes possible greater simplicity of mounting, economy of design, assembly and maintenance costs. For complete information call your Fafnir Representative. The Fafnir Bearing Company, New Britain, Conn.

PILLOW BLOCKS
. . . standard and heavy series
FLANGE CARTRIDGES
. . . standard and heavy series
CYLINDRICAL CARTRIDGES
. . . . standard and heavy series
WIDE INNER RING BALL BEARINGS
. . . with Mechani-Seals

FAFNIR
BALL BEARINGS
MOST COMPLETE LINE IN AMERICA





Revolving Joint For Air and Hydraulic Use

Designed for making air or hydraulic piping connections to clutches, power transmission drive units, chucks, spindles, grinding wheels and other rotating machine parts, this light running, ¼ in. ID revolving joint has the following features: (1) a compact one-piece bronze casing; (2) special spring loaded V-ring seals; (3) hardened and ground steel shaft; (4) permanently lubricated, sealed ball bearing. All parts are readily removable and replaceable.

Connection to rotating machine or part is made by screwing the male threaded steel shaft of the joint into the hub of the chuck or clutch. Connection to the stationary end of the joint may be by pipe or flexible hose. Use of hose is recommended to make a free-floating installation. Overall length of the joint is 3⅜ inches. When installed it projects only 3⅛ in. beyond the hub.

The joint is suitable for use at temperatures up to 180 F and pressures to 300 psi (air) or 1,500 psi (hydraulic). Maximum speed ordinarily recommended is 2,500 rpm for normal applications with lower speeds possible for high pressure and high temperature conditions.

Barco Mfg. Co., 500 Hough St., Barrington, Ill.

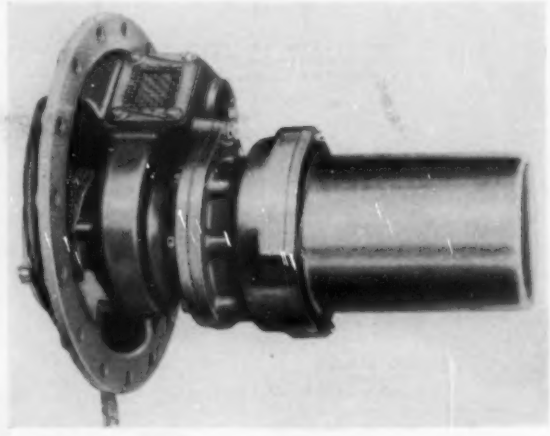
Booster Pump Prevents High-Altitude Vapor Lock

This new submerged fuel booster pump is specially designed to separate vapor from fuel at the supply tank so that a solid line of fuel is pumped under pressure to the engine driven pump. This prevents vapor lock in the line which would otherwise stop fuel flow or impair the function of the engine driven pump. A secondary purpose is to transfer fuel from one tank to another, such as to a main tank from which vapor-free fuel is boosted to the engine driven pump.

Known as model RR-11050, the unit is basically designed to MIL-P-5243, type E-18B fuel booster pumps and meets the qualification requirements specified under MIL-P-5238. Performance of the pump is given as: 6,000 lb of fuel per hr at 15 psi; 0 to 50,000 ft altitude; climb conditions of 7,500 ft per minute. The weight is 9.25 pounds.

A single armature shaft, which drives the main impeller and vapor separating impeller, runs on two ball bearings and permits the pump to operate without harm under dry tank conditions. To completely empty the tank the design utilizes a screened inlet located in a deep sump, with the main impeller in close proximity to the inlet. This screened section is removable with the sump cover for cleaning.

The motor is rated at 0.47 hp, 27 v, d-c, 8,000 rpm, 20 to 21 amp at rated load. Radio interference filter is optional. The mechanical seal, located under the motor, is drained to assure a dry, vapor free motor. A leak proof and explosion proof cover enclosed the motor, which is internally vented through mounting flange.



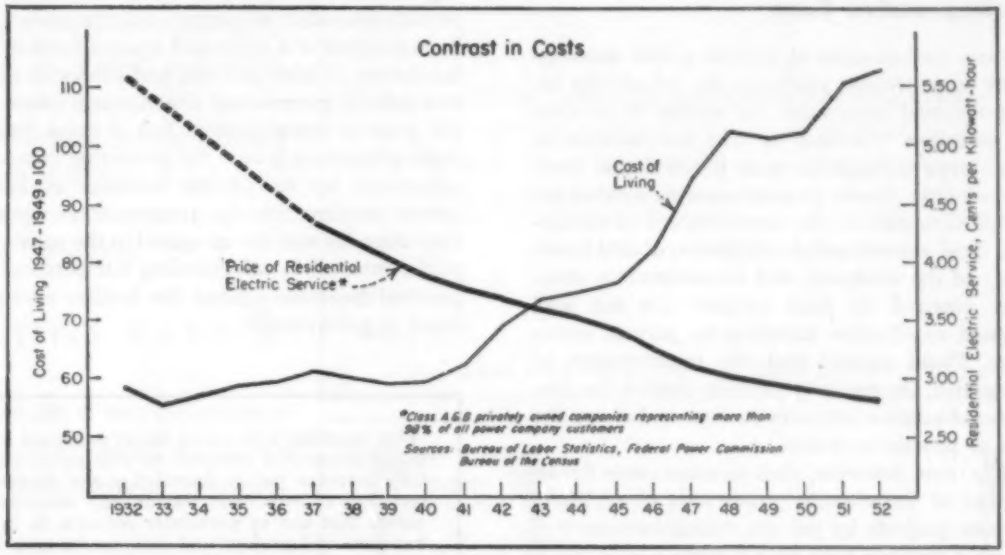
Lear, Inc., Lear-Romec Div., Elyria, Ohio

CONTINUED ON PAGE 226

A 20-YEAR RECORD...

The Electric Power Companies' Case for Public Confidence

An economic study of the record of the investor-owned electric power companies of the United States over the past twenty years underwrites their claim to public confidence today. A key factor of this record is set forth by the chart in the middle of this page. This shows that while the cost of living as a whole has almost doubled, the average price of electric energy for residential use in the United States has been cut in half.



The average prices of industrial and commercial power also are much lower than they were twenty years ago.

Such a study confirms the record on other key accomplishments of the electric power companies during the past two decades.

They have not failed, either in peace or war, to meet the nation's rapidly expanding electric power requirements. In paying tribute to the performance of these companies during World War II, J. A. Krug, Director of the Office of War Utilities, said, "Power has never been too little or too late." The same can be said for the entire period of the past twenty years.

To be ready with enough power – on time – the electric power companies have expanded their production fourfold since 1933. This has required an investment of over $17 billion in new facilities. To raise the funds for this investment they have enlisted the participation of about 3 million direct stockholders. Through life insurance companies, banks and similar institutions, about 90 million Americans – more than half of the nation's total population – have become investors in electric power companies. By thus relying on private investment for their expansion, the power companies have provided their

plant and operating equipment without burden on the taxpayer.

In addition, the investor-owned companies have paid about $12 billion in taxes to various governments – national, state and local – over the past twenty years. Unlike government-owned and -operated systems, they have received no public subsidies. When taxes and subsidies are taken into account, the rates for electricity charged by the investor-owned companies have been as low as, or lower than, those charged by government-owned and -operated systems.

Many Americans do not appreciate the job that the power companies have done over the past two decades. That is due, in part, to the public memory of financial abuses by some utility holding companies during the 1920's. This memory obscures a clear and unprejudiced view of the progress since those days. And some of the all-out advocates of reliance on government rather than on regulated private enterprise for the development of our power resources do their best to keep this memory of the past alive in the present.

An Impressive Case

Some special cases of electric power development may involve problems for which the investor-owned companies are unable to provide full solutions. This may be true, for example, of some large multiple-purpose projects that combine electric power generation with related developments such as the improvement of navigation, flood control and the irrigation of arid lands. Some of the economic and administrative problems imposed by such projects are not well adapted to effective handling by private enterprise. Flood control and the improvement of navigation, for example, usually involve the provision of much costly service over and above the cost of producing power.

It is true, however, that in some cases development of the electric power side of multiple-purpose projects by private enterprise may well be more feasible than would appear from statements by some government power advocates. And the record indicates that even in those projects on which both the power generation and the other services are handled by public authority, it may well be desirable to have the investor-owned companies assume the transmission and distribution functions.

Our study of the record of the investor-owned and -operated companies over the past twenty years has led us, of course, behind the statistics that bear on the wisdom of giving them a priority in the development of our power resources. It reveals that these enterprises are manned by people who, through lifetime experience, are peculiarly conversant with the needs of the communities they serve. They have given the consumer notably good service while conforming to standards set and enforced by public regulatory commissions. They have won the confidence of the investing public. By their nature and their experience they are competent to handle any power program that can be demonstrated to be economically sound.

The Paramount Public Interest

By their economic performance during the last twenty years, the electric power companies have earned the confidence of the public. By relying on these companies to meet its electric power requirements the public will fully protect its economic interest in ample and efficient service at fair prices.

That is where our study comes out. Our findings do not touch the political consideration that private operation of electric utilities under public regulation is a safeguard against further concentration of both political and economic power in a federal government that already commands too great a concentration. But if these findings make an economic case for preferring power development by tax-paying business as against power development by governmental agencies, they clear the way for an appeal to the paramount public interest in safeguarding our personal and political freedoms against the further encroachment of government.

This message is one of a series prepared by the McGraw-Hill Department of Economics to help increase public knowledge and understanding of important nationwide developments that are of particular concern to the business and professional community served by our industrial and technical publications.

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To be sure that your request will receive prompt and careful attention, please write or print legibly your name, company affiliation, and address. This service is valuable to you only if you use it. We welcome your comments and suggestions at any time.

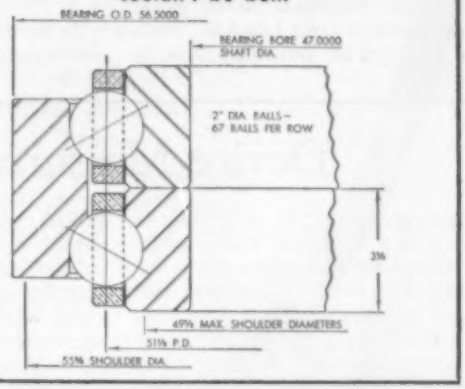
Here are the bearings that "couldn't be built"... *as produced by Kaydon*

THE manufacturer who wanted these bearings had been told they "couldn't be built." Or at least that's what he'd been told *until* he contacted **KAYDON**. What he required was a bearing 56½" in diameter combining high capacity, and exceptional precision for concentricity and face runout that would fit in limited space.

KAYDON designed a double-row angular contact ball bearing (see sketch at right). Actual tests have proved that the bearing fulfills every requirement.

If your designs require special bearings — bearings of exceptional strength, close-tolerance precision and/or very thin section — it will pay you to contact **KAYDON** of Muskegon. **KAYDON** has a long-standing reputation for accomplishing the near impossible.

CROSS SECTION — *The bearing that couldn't be built*



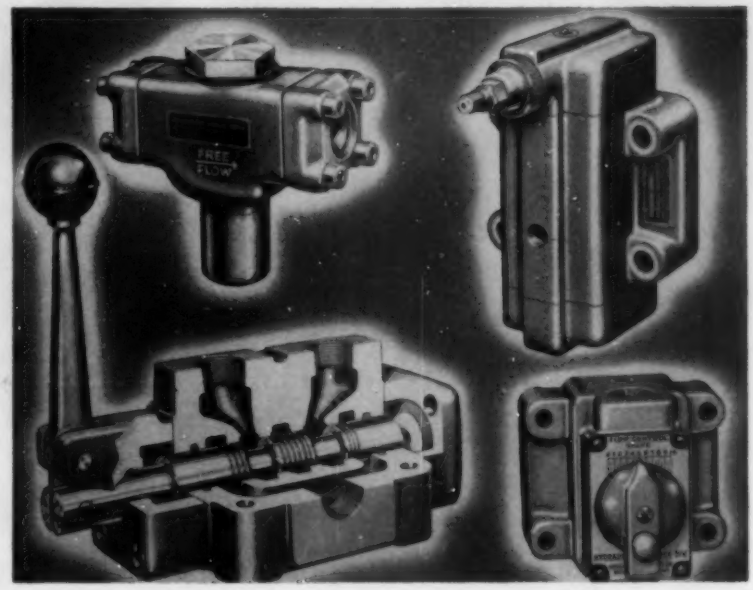
KAYDON Types of Standard and Special Bearings:
Spherical Roller • Taper Roller • Ball Radial • Ball Thrust
• Roller Radial • Roller Thrust • Bi-Angular Bearings

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

PRECISION BALL AND ROLLER BEARINGS

New Design Features in Hydraulic Valve Line



Features of a new line of hydraulic valves like those shown in the illustration include a full floating operating lever on direction valves to give "feel of the control;" O-ring seals on each end of the valve body to give leakproof operation; full flow design for a minimum of pressure drop through the valve; long lands on both the valve body and spool to prevent binding of the spool; fitted spools; machined inlet and cylinder ports; and interchangeable end caps to permit changing of the valve assembly to reverse valve ports.

Having more than 3,500 basic models, the new valve line consists of directional and functional valves, each available with optional body styles, types of control, methods of operating, and other features for universal application.

Directional valves are offered in threaded, flange and gasket mounted types for maximum pressures up to 3,000 psi. The 4-way and 2-way threaded valves range in size from $\frac{1}{4}$ to $1\frac{1}{2}$ in. for 2,000 psi service. There is a choice of manual, cam, foot, solenoid, oil and air pilot operation, and six spool styles for almost every model. Standard types of control include stem, knob, lever, and a new quadrant lever locking device which offers special safety features for positive positioning. These same models, types of operation, and sizes are also available with flange connections for 3,000 psi. An equally complete line of gasket mounted valves from $\frac{1}{2}$ to 4 in., 2,000 and 3,000 psi are available and rotary pilot valves are also included in the line. There are 3,175 models of directional valves, all designed for maximum service.

Functional valves include relief, sequence, unloading, pressure reducing, counterbalance, flow control and check valves. The valves with threaded connections are available in sizes from $\frac{1}{4}$ to $1\frac{1}{2}$ in. for 2,000 psi. Flanged valves range in size from $\frac{1}{2}$ to $2\frac{1}{2}$ in. for 3,000 psi; gasket mounted valves from $\frac{1}{2}$ to $2\frac{1}{2}$ in. for 2,000 and 3,000 psi.

In the illustration, the cutaway view shows features of the 4-way, 2,000 psi threaded valve. At the top left is a 3,000 psi horizontal, pilot-operated check valve with flange connections; at the top right is a 3,000 psi, gasket-mounted, vented-type relief valve with balanced piston; and at the bottom right, a 2,000 psi, adjustable flow control valve with threaded connections and featuring automatic pressure compensating design.

More information on these valves may be obtained from the manufacturer.

The Hydraulic Press Mfg. Co., Lincoln Ave., Mount Gilead, Ohio

Device Measures, Plots Two Functions

Designed essentially as a research tool, a new instrument known as the Electronik duplex function plotter automatically measures two variable conditions and simultaneously plots their relationship to a third. The manufacturers claim that the new instrument will be useful in a wide range of industrial research activities from missile and engine testing to stress and nuclear engineering analysis. In aerodynamic research, for example, it can plot vibration amplitude and discharge pressure vs speed, or dynamic pressure and yaw angle vs immersion depth.

The instrument incorporates three complete measuring and balancing circuits. While two of these circuits actuate recorder pens horizontally across a specially calibrated chart to record two conditions, the third circuit motivates the instrument chart, up or down, as it measures the third variable. The result is a continuous, automatic plotting, which evaluates the two initial variables in terms of the third one. All three circuits can be actuated by any d-c source, and can be calibrated for the same or different ranges and actuations. One pen may record temperature; the second pen, speed; while the chart measuring circuit is calibrated in milivolts to represent the third variable, such as pressure.

Among the advantages of the new instrument are that the measurements are automatically compiled and the curve montinuously plotted.

Minneapolis-Honeywell Regulator Co., 4494 Wayne Ave., Philadelphia 44, Pa.

CONTINUED ON PAGE 228

TITANIUM RINGS?

... sure we make them

In 1950 American Welding completed the first successful production flash butt-welding of the new wonder metal — Titanium Alloy. Since that time hundreds of Titanium components have been produced in our plant.

If you use, or are planning to use, fabricated Titanium components, let our Product Development Division study your problem. Our factory is equipped to perform welding, machining, and fabricating of all types of ferrous and non-ferrous metals.
Call or write us today!

THE AMERICAN WELDING & MANUFACTURING COMPANY • 140 DIETZ ROAD WARREN • OHIO

Universal Torsion Spring Tester

A universal tester to check loads and deflections of torsion, double torsion, spiral, clock and power, springs is now commercially available. The manufacturers claim that it will find use in inspection departments of spring and product manufacturers, government arsenals, and laboratories.

Although useful for general purpose testing, it can be used for high quantity production testing of torque and angular travel at speeds of 300 to 600 tests per hour. It meets the requirements of the National Bureau of Standards for precision scales, and is said to be guaranteed accurate within $\frac{1}{4}$ of 1 percent.

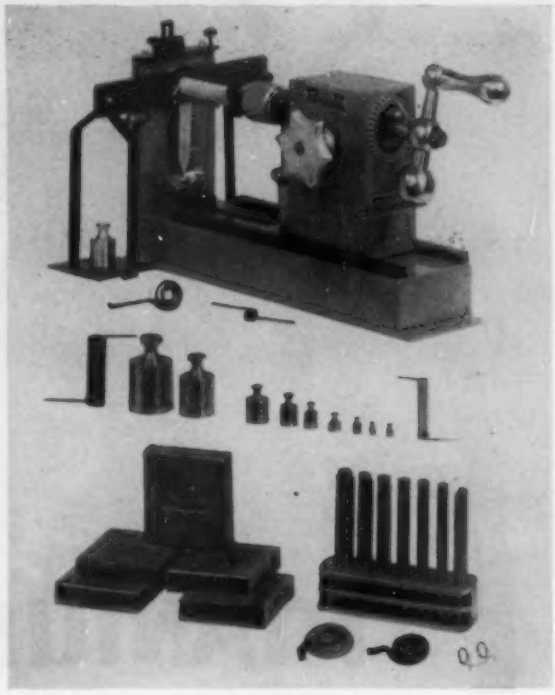
The tester will handle: torsion springs having wire diameter from 0.005 in. to 0.125 in., outside diameter from $\frac{1}{16}$ in. to 6 in. lengths from $\frac{1}{16}$ in. to 6 in., can be tested for torque from $\frac{1}{4}$ in.-oz to 48 in.-pounds.

To operate, simply insert an arbor into the chuck, with one spring arm against the screw on the beam and the other arm against the screw on the chuck bar, set the protractor arrow to zero, turn the handle any number of revolutions or degrees required, and place weights in the pan until the pointer registers at zero. Weights are specially marked to show torque.

The accessories with the instrument are: 15 arbors $\frac{1}{16}$ in. to $\frac{1}{2}$ in., block of weights $\frac{1}{4}$ in.-oz to 4 in.-lb, five 8 in. lb weights and two adapters for extremely small springs, are provided.

Dimensions are: 9 in. high, 11 in. wide, $15\frac{3}{4}$ in. long.

The Carlson Co., 277 Broadway, New York 7, N. Y.



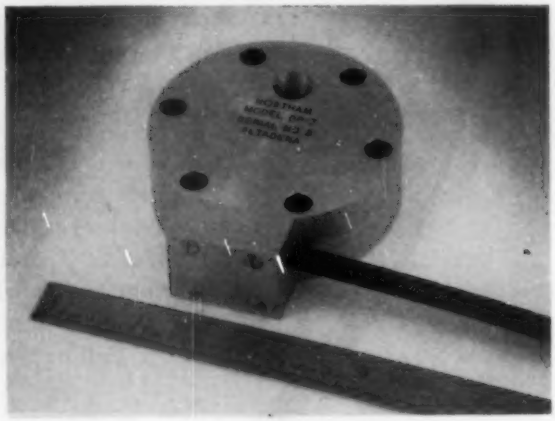
Pressure Transducer For All Gases and Liquids

The model DP-7, sensitive pressure transducer, is a sensitive instrument for the measurement of differential pressure in terms of electrical output. The range of working fluids covers all non-corrosive gases and liquids, and the design allows a selection of working ranges from ±0.5 to ±15 psi differential at line pressures up to 100 psi. The instrument will withstand the application of maximum line pressure in either direction.

Applications include laboratory testing, radio telemetering and process control where precise measurement of low differential pressure is required, both statically and dynamically. The instrument has been used to measure water depth variations as small as 0.002 in. at the base of a water column 4 ft high, with an accuracy of 2 percent of the variation range at frequencies from 0-30 cycles per second.

Operation is based on the variable reluctance principle. Absence of mechanical loading on the pressure sensing diaphragm results in a high natural frequency, essential for good dynamic response and freedom from mechanical shock excitation. The natural frequency corresponding to a range of ±1 psi is 1,000 cycles per second.

The output is derived from two inductances which vary 10 percent in opposite directions with application of full pressure. The instrument will operate in a-c carrier systems from 60 to above 10,000 cycles per second with an accuracy, including non-linearity and hysteresis effects, of 1 percent full scale. When operated in a bridge circuit at 3 kc, the full scale output is ±50 millivolts per volt and the maximum excitation is 50 volts. Operation is on 115 v 60 cycle.



North American Instruments, Inc., 2420 N. Lake Ave., Altadena, Calif.

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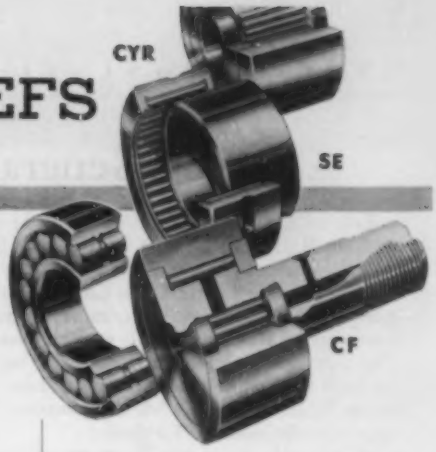
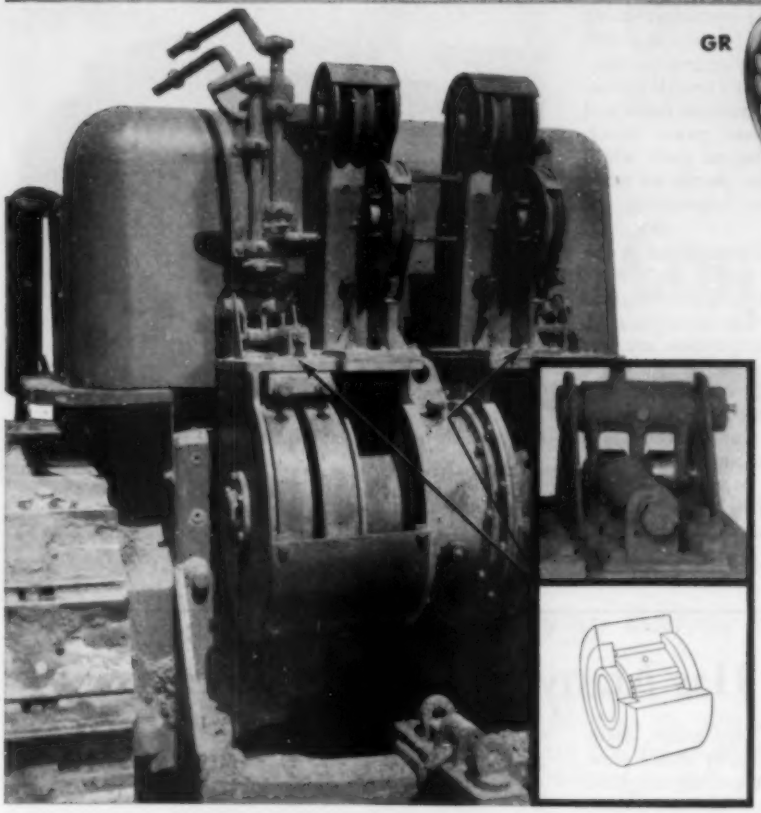
McGILL BEARING BRIEFS





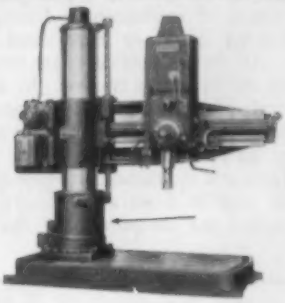
MULTIROL® CYR Bearings

HELP PROVIDE "POSITIVE ACCURATE CABLE CONTROL" on GarWood Cable Control Units

It takes dependable, precision bearings to achieve the "fast, accurate control" featured in Gar Wood Cable Control Units. That's why Gar Wood has standardized on Multirol CYR Bearings as cam rollers on the control arms. The Model 281 unit uses 4 CYR bearings to enable precise, frictionless adjustment of control cables on each of two drums that handle a scraper or dozer blade. CYR Bearings have a thick outer race section to withstand the heavy shock loads encountered in such cam applications. They help make the Gar Wood Cable Control a rugged, hard-working unit that stops and starts smoothly.

Multirol CYR Bearings are built to provide longer life and greater efficiency in cam operations. They are labyrinth sealed by roller retaining end plates tightly fitted and secured to the shoulders of the inner ring. Yoke mounting is possible where desirable on shaft sizes ranging from ¼" to 1¼" for corresponding roller diameters of ¾" to 4".

FOSDICK DRILL HEADS POSITIONED BY CYR BEARINGS



Fosdick Machine Tool Company uses Multirol CYR Bearings to provide rigid and accurate support between inner and outer columns of this Hydraulic Radial Drill. The CYR Bearings act as guide rollers between columns to provide precision positioning of the drill head.

CYR BEARINGS REDUCE FRICTION ON VALVAIR VALVES

Changing the cam roller on this Valvair 4-way cam operated valve to a Multirol CYR Bearing reduced friction on the cam plate and eliminated elongation of the hole in the cam arm. Since replacing friction type rollers with CYR Bearings, they have never had occasion to replace either the cam roller or the cam arm.

BEARING SELECTION GUIDE

A new 140-page Bearing Selection Guide, complete with 30 pages of vital engineering data, has been released by the McGill Manufacturing Co. Ask for Catalog No. 52.

McGILL® —Precision Bearings

McGILL MANUFACTURING COMPANY, INC.

201 N. Lafayette Street, Valparaiso, Indiana

General Purpose Digital Computer

Ease of maintenance and simplicity of operation, along with small size and low cost, are the main features of a new digital computer for use in the research laboratory or engineering firm. Called the Circle Computer, its overall dimensions are 3 x 4 x 6 feet. It contains 700 vacuum tubes and consumes 3½ Kw from a 110 v single phase power source. The computer is built up from small logical units which are each built on a separate chassis. These chassis are easily accessible for checking while the computer is operating, and may be easily removed for service.

A magnetic drum rotating at 59 rps is employed as the memory element. Its capacity is 1024 words. Each word consists of forty binary digits plus two sign digits—equivalent to 12 decimal digits plus sign. The multiplication time is 45 milliseconds. Example of computation are: ray tracing; design of servos; and data reduction and analysis.

All the controls necessary to operate the computer appear on the operators console. In addition, neon lights on the control panel allow the operator to monitor the computers course in a calculation. Input to the computer is by means of an electric typewriter or a punched paper tape reader. Data and instructions may thus be typed in by the operator or read in from a previously prepared paper tape. For output the computer may operate an electric typewriter, a paper tape punch or both. Intermediate results as well as the final results of a calculation are available any time during the process at the operators discretion.

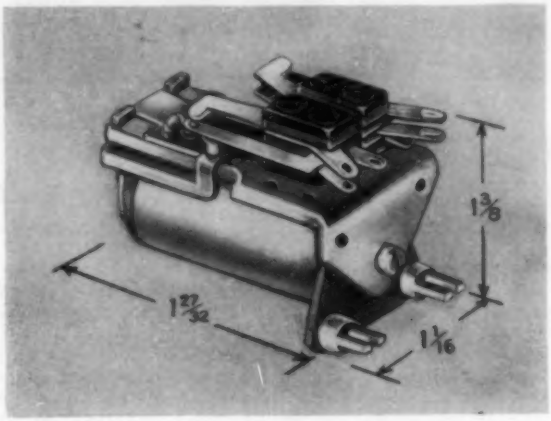
Nuclear Development Associates, Inc., 80 Grand St., White Plains, N. Y.

Sensitive Relay Has Many Contact Combinations

A new series of versatile, telephone type relays, designated as class 22 are furnished in hermetically sealed, dust-tight enclosed, and open types, and are especially adaptable to low wattage sensitive applications and for requirements where on relay must perform a large number of switching functions with minimum input power.

They can be furnished with great resistance to shock and vibration, and to withstand wide temperature variations. Coil and contact spring terminals at the mounting end of the relay permits concealed wiring of either individually or strip mounted relays.

The relay is available 60 cycle, a-c, any voltage to 440; d-c, any voltage to 230. It is furnished with a great variety of contact combinations; single or twin contacts; snap action contacts; coil resistance from 0.12 to 21,000 ohms; time delay—slow release to 125 milliseconds.



Magnecraft Electric Co., 1442 W. Van Buren St., Chicago 7, Ill.

MULTI-PURPOSE BALL AND ROLLER BEARING GREASE replaces nearly all special lubricants, has no melting point and will not break down or bleed, even at very high temperatures. Can be pumped at temperatures below 0 F. Called no. T/S-21, it is water resistant Tri-State Petroleum Co., 81st & Eastwick Ave., Philadelphia 42, Pa.

THE ELLIPSOGRAPH is a new drafting instrument which produces mathematically true ellipses with speed and precision, and has a capacity of over 12 in. major axis. All sizes, shapes and projections of ellipses can be drawn with either pencil, inking pen or scriber. The Omicron Co., P. O. Box 907, Glendale, California.

A PORTABLE ULTRASONIC INSTRUMENT will measure the thickness of steel sheet where only one surface is available, and will test the continuity of bonds and raw stock for defects. Works with steel thicknesses from 0.014 to 0.400 inch. It uses high accelerating voltages, slow sweep speed. Sperry Products, Inc., Danbury, Conn.

CONTINUED ON PAGE 232

HERE'S PROOF: You can always count on Continental for every fastener need!

Continental Controls Every Phase of Fastener Production!

. . . to guarantee you better quality

From wire drawing to shipping, Continental controls every phase in fastener production under its own roof. Even the tools used are made in the plant. Every step beginning with the design engineer is carefully supervised and checked to insure the finest product possible. Their unequaled Quality Control System is constantly working to protect you.

Whenever special or standard fasteners are being considered, remember that quality production is assured at Continental—it is not just a term—but a rigid policy of perfection.

Call us today or check your nearest Continental distributor for information. You'll get complete control in every step . . . backed by 50 years of fastener experience.

Manufacturers of HOLTITE Fastenings

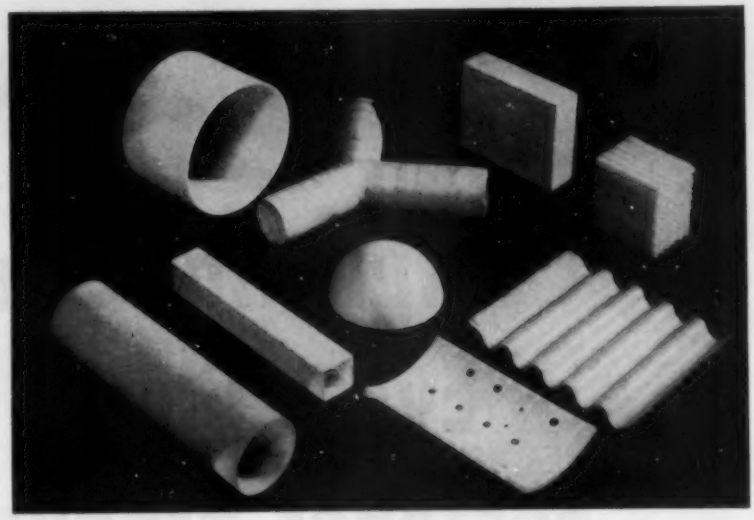
CONTINENTAL SCREW COMPANY INC. 1904

50th Anniversary

CONTINENTAL SCREW COMPANY

New Bedford, Mass., U. S. A.

Sillicone-Glass Laminates Offer High Strength



Low pressure silicone glass laminates with initial strength and stiffness values approaching those of the organics are being made with a new bonding resin 2106. Typical $\frac{1}{8}$ in. samples (30 percent resin, heat cleaned 181 cloth) show flexural strengths in the range of 50,000 psi at room temperature even before curing. The resin has good flow characteristics and, uncatalyzed, has a gel time of 5 to 10 min. at 480 F.

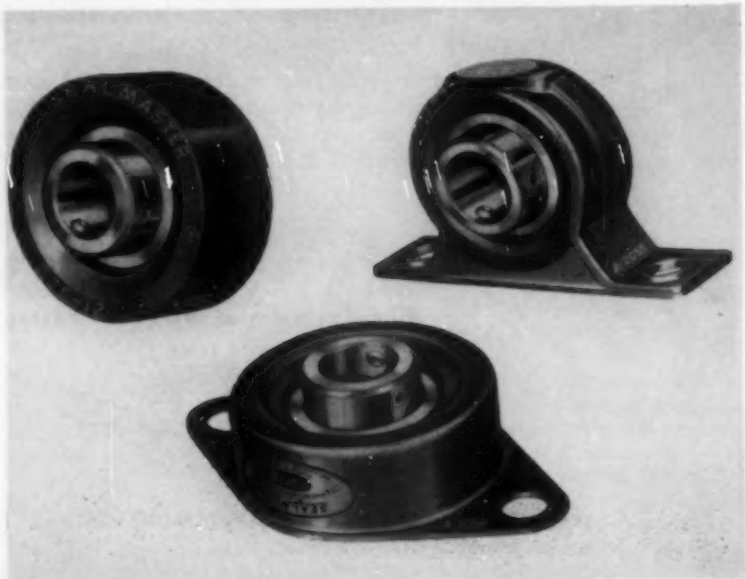
High temperature strength is obtained after relatively short cures. Optimum strength is attained after 80 hr at 480 F, or less than half the cure formerly required. Flex strength of 10,000 psi at 500 F is reached in 6 hr, indicating that in many applications, these laminates may be cured in service. Also, high physical strength is retained after prolonged aging at extreme temperatures.

Laminates bonded with 2106 resin are highly water repellent and resistant to many common inorganic reagents. Their bond strength, at over 1,000 lb, is comparable to that of the organics, as are their elastic moduli. Their heat resistance and dielectric properties qualify them for use as class H insulating materials as defined in the AIEE Standards No. 1.

According to the manufacturer, the properties of 2106-bonded laminates suggest their use in various industrial or aeronautical structural parts which must combine light weight and high strength at elevated temperatures. While most samples to date have been laminated at 30 psi or less, indications are that laminates may also be produced with high pressure equipment.

Dow Corning Corp., Midland, Mich.

Rubber Mounted Ball Bearing Units



Rubber mounted ball bearing units are now available with pressed steel housings in six shaft sizes, ranging from $\frac{1}{2}$ to 1 inch. They are available as pillow blocks, flange units, and cartridge units.

The new bearings are designed for reduction of noise and vibration and are said to be particularly adaptable for use on air conditioning equipment and other light duty applications. The synthetic rubber mounting rings are oil and grease resistant and the bearings are lubricated for life.

The zone hardening process used on the inner race ring of ball bearing units heat treats through the ball path section only. Since the extended portions of the race remain unaffected, the hardened threads of the set screws bind tightly against the soft threads of the race for race to shaft locking.

Stephens-Adamson Mfg. Co., Sealmaster Div., Aurora, Ill.

CONTINUED ON PAGE 234

Need a SPECIAL material?

LAVA • SILICON CARBIDE
ALUMINA (vitrified or porous) • CORDIERITE
STEATITE • ZIRCONIUM OXIDE • ZIRCON
MAGNESIUM SILICATE • ALUMINUM SILICATE
FORSTERITE • TITANIUM DIOXIDE

SEE OUR DISPLAY
BOOTH NO. 340
BASIC MATERIALS EXPOSITION
The Product Development Show
CHICAGO
MAY 17-20, 1954

Development of new, special purpose ceramic compositions is a regular part of our work. No matter what your requirements are, the chances are good that we have an AlSiMag composition that will do the job.

If you need a material with special characteristics or have a difficult design involving intricate shapes or close tolerances, give us your requirements. Let us show you what we can do.

53RD YEAR OF CERAMIC LEADERSHIP

AMERICAN LAVA CORPORATION

A Subsidiary of Minnesota Mining and Manufacturing Company

CHATTANOOGA 5, TENNESSEE

OFFICES: METROPOLITAN AREA: 671 Broad St., Newark, N. J., Mitchell 2-8159 • SYRACUSE, N. Y.: 204 Harding Place, Phone 9-0656 • CLEVELAND: 5012 Euclid Ave., Room 2007, Express 1-6685 • NEW ENGLAND: 1374 Mass. Ave., Cambridge, Mass., Kirkland 7-4498 • PHILADELPHIA: 1649 N. Broad St., Stevenson 4-2823 • ST. LOUIS: 1123 Washington Ave., Garfield 4959 • CHICAGO: 228 W. LaSalle St., Central 6-1721 • SOUTHWEST: John A. Green Co., 6815 Oriole Dr., Dallas 9, Dixon 9918 • LOS ANGELES: 5603 N. Huntington Dr., Capitol 1-9114

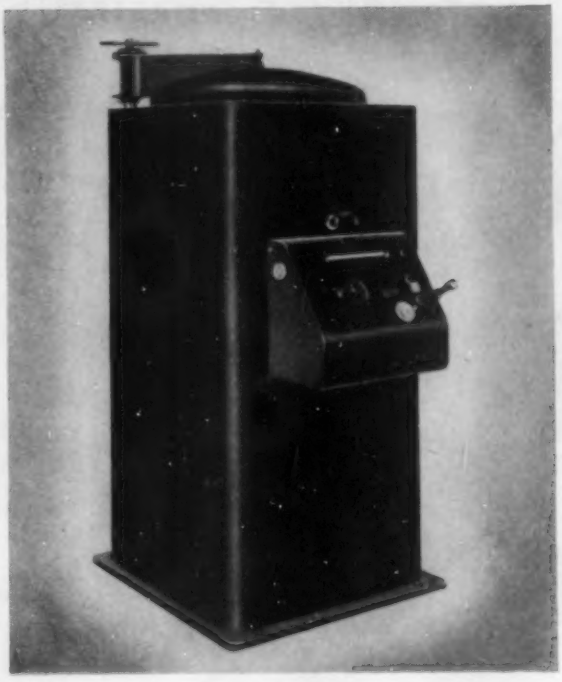
Wide Range High Speed, G-Accelerator Unit

Capable of testing accelerometers and other instruments under acceleration forces up to 850 G's, a G-accelerator machine has a range infinitely variable from 20 to 1,750 rpm, with a radius of gyration variable from 5 to 12 inches. This gives a G-range of from 0.61 to 850 G's.

The mounting platform of the new model D consists of a circular table 24 in. in dia, with 108, ¼-20 tapped mounting holes. These are arranged in a regular 2 in. equilateral pattern for ease in mounting test objects. Full capacity of the table is 1,000 G-pounds. As many as 6 identical objects can be tested simultaneously if arranged symmetrically on the table. The table has been carefully balanced, to equalize the weight of electrical leads. Supporting the motor and transmission on shock mounts and flexible couplings, isolates the table from vibration and pulsation.

The test chamber can be sealed off for altitude tests with leakage less than one pound per square inch per minute. Design of the outer shell also permits the test chamber to be insulated for thermal tests.

The drive mechanism consists of 1 hp, 220 v, 60 cycle, 3 phase motor and an infinitely variable, hydraulic transmission with a ¾ hp output. All critical bearings are sealed for life and require no maintenance. Table rotation is controlled by a direct mechanical leadscrew and handwheel, operating against an anti-backlash spring. Traverse of the full range requires 22 revolutions. Through a manually-operated lever, independent of the speed control handwheel, the table can be braked to a full stop from full speed in approximately 10 seconds. The instrument has two systems for determining table rotation speed: a tachometer, accurate to 1 percent from 200 rpm; and a strobe system.



Genisco, Inc., 2233 Federal Ave., Los Angeles 64, Calif.

Large, Multiple Surface Filters

Compact, large capacity filters with filter areas up to 720 sq ft and cake space capacity up to 35 cu ft are now available using as a filter medium high temperature resistant porous stainless steel.

The container can be either carbon steel or stainless steel for corrosive service. Its compact design permits steam jacketing, high pressure construction, sanitary construction, and ease of cleaning. Other filters of this type can be designed for specific applications.

The illustration shows a filter with 30 sq ft of filter area housed in a stainless steel container 12 in. in dia by 20 in. long.

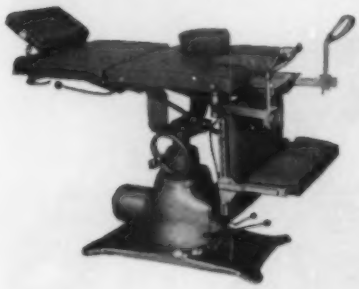
The porous stainless steel filter medium prevents the "break-through" point, or pressure above which clarity of filtrate is no longer obtained, and is said to be the best support medium for filter-aid, since it will not pass filter-aid during any portion of the filtration cycle.

These filters are recommended for clarification service and solids collection in service with such diverse fluids as water, petroleum products and molten metals. In some cases these filters have been used in service over a two year interval in these and many other applications.

Micro Metallic Corp., Glen Cove, N. Y.

CONTINUED ON PAGE 236

Choice of leading physicians is this motor-elevated medical specialists table made by Ritter Company. To minimize the discomfort of patients its tilting mechanism is Aetna bearing-equipped for effortless, smooth, quick adjustments without irritating jolting and jarring.



ARMCO

This drainage gate hoist made by Hardesty Division—Armco Drainage and Metal Products, Inc., may be installed in some isolated spot remote from repair service should trouble develop. That's one reason why it is Aetna bearing-equipped—why, even if not used for long periods of time, it will operate easily, efficiently and dependably.

IDEAL

Ideal Windlass Company, manufacturers of deck machinery for pleasure and commercial boats, uses Aetna bearings in all models of their electric anchor windlasses to help handle anchor loads of 500 pounds and more in minimum space, at maximum speeds—to reduce wear on other working parts, save electric power and insure trouble-free, longer equipment life.

ABRASIVE

ACCURACY BOOSTS PRODUCTION

Abrasive Machine Tool Company makes sure its surface grinders have what it takes to stay on non-stop jobs with minimum maintenance and downtime by using Aetna bearings on the elevating screw in the head assembly of this No. 1218 type horizontal spindle grinder.

AETNA BEARINGS

bring important advantages to these fine products

Here are widely varied examples of Aetna bearing applications. Why are they used in such mechanically simple products as medical tables and drainage gate hoists? The answer is simple. Aetna bearings make any moving device—big or small, simple or complex—more efficient, more serviceable, more salable.

Consider your own product. Is it one of the many that still doesn't—but could—use bearings? If it is and if you want to put it out in front of competition, value-wise and sales-wise it might pay you handsomely to talk things over with Aetna. Write now while your mind is on your product's future.

Standard and Special Ball Thrust Bearings • Angular Contact Ball Bearings • Special Roller Bearings • Ball Retainers • Hardened and Ground Washers • Sleeves • Bushings • Miscellaneous Precision Parts.

AETNA BALL AND ROLLER BEARING COMPANY

DIVISION OF PARKERSBURG-AETNA CORPORATION

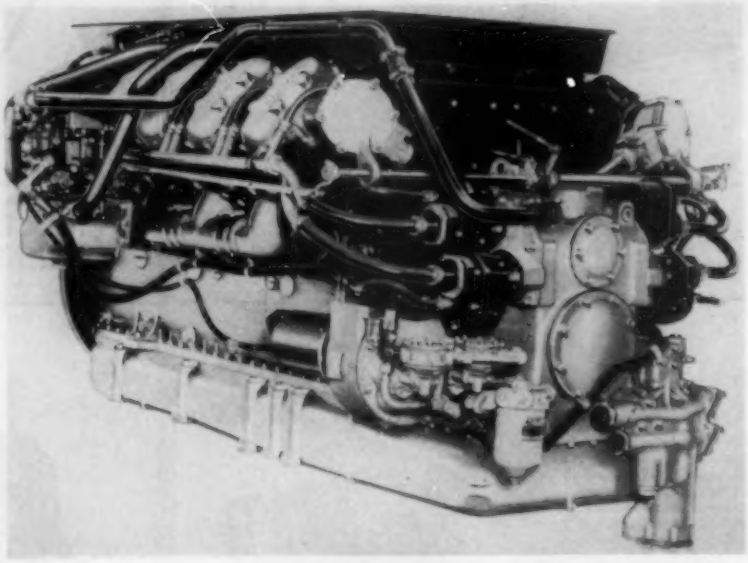
4600 SCHUBERT AVENUE • CHICAGO 39, ILLINOIS

High-Output Military Engines for Commercial Use

The line of high-output internal combustion engines that was specifically developed for tanks and other military vehicles is now available for commercial use. Changes in the models have pushed the output ceiling from 200-plus hp to beyond 1,000 hp to increase their applications.

Models of these air cooled engines that are available range from 375 to 1,040 hp, and feature high output, combined with light weight, compactness, versatility, and ease and economy of servicing. This line includes the 6-cylinder 375 hp AO-895-4 which powers U. S. tanks; the 500 hp supercharged version, AOS-895-3; the 12-cylinder 810 hp AV-1790-7; and its supercharged version which develops 1,040 hp. The model LV-1790-1 also has 12 cylinders, is rated at 810 hp, but is the only liquid cooled unit.

All have twin ignition, making them as dependable as an aircraft engine. Each of the two spark plugs in each cylinder is fired independently.



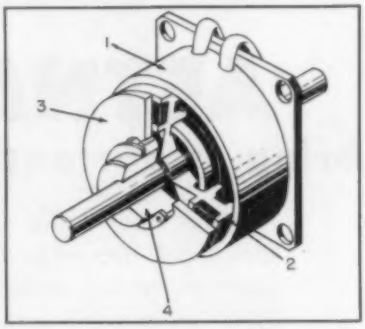
Continental Motor Corp., Muskegon 82, Michigan.

Fast, Accurate Control of Low Torque Drives

Smaller than a man's hand, these new replaceable face electric brakes and stationary field electric clutches are said to offer several outstanding advantages for a wide variety of power transmission applications.

High-speed engagement and release, coupled with high torques make the units adaptable to starting, stopping, indexing, rapid cycling, synchronizing, torque limiting, indexing and jogging, and single revolution cycle application on small, electrically operated instruments and machinery. Pushbutton or automatic operation with limit switches, relays, electric eyes, and other electric controls makes possible design opportunities heretofore limited by slow, mechanical linkages, size, and weight requirements, according to the manufacturer.

The new brakes have just two parts, a rotating armature and a stationary field with replaceable face. Clutches and clutch-couplings have only three working parts, a stationary field, rotor and armature. All units operate on 6 to 15 watts of direct current.



In operation, when the clutch field coil is energized, flux flows from the field to the rotor, which attracts the armature for coupled driving. Brake flux pattern is the same except the stationary field attracts the rotating armature for instantaneous stopping. With special controls, response times measured in milliseconds are possible.

Torque build-up is always smooth until "lock in" after which engagement is positive with no creeping or slipping. Torque ratings of these new drives are from 8 to 240 in.-pounds.

Rated speeds for these units are: model 160, 10,000 rpm; model 250, 7,200 rpm; model 400, 4,500 rpm.

Shown above left is the stationary field electric clutch coupling; and right a cutaway view of the replaceable face electric brake. Some of the parts labeled are: (1) the stationary field; (2) armature; (3) replaceable friction surface; (4) and the armature hub.

Warner Electric Brake & Clutch Co., Beloit, Wis.

CONTIUED ON PAGE 238

A wide variety of designs and sizes of sleeve bearings, cast bronze bushings, precision bronze parts, bi-metal and rolled split bushings, washers and spacer tubes. Research, engineering, quality control, large-volume production.

FEDERAL-MOGUL CORPORATION
11043 Shoemaker • Detroit 13, Mich.

FEDERAL Mogul
Since 1899

FEDERAL-MOGUL

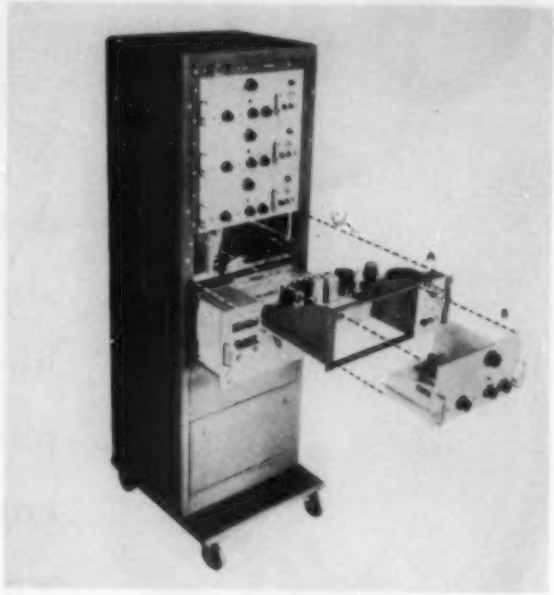
Four-Channel Oscillographic Recording System

A new four channel oscillographic recording system, provides a unique combination of interchangeable "plug-in" elements which make the system applicable to the graphic registration of almost any phenomenon (individually or up to four simultaneously) within the frequency range of zero to 100 cycles per second.

Called the model 150, the system consists of a vertical cabinet containing a four channel recorder assembly, and a built-in driver amplifier and power supply unit (A in illustration), which are already in place, for each of the four channels. The preamplifier (B in illustration) required for the specific application is plugged in to the appropriate channel. By changing the plug-in preamplifier, the system is adapted to recording a wide variety of phenomena including stress, strain, pressure, displacement, thickness, velocity, acceleration, current, voltage, temperature, torque, light, flow, force, load, position, rpm, radiation and tension.

Standard plug-in preamplifiers now available include: a-c d-c, carrier, d-c coupling, servo monitor, log-audio, and low level. Blank plug-in assemblies are also available so that the user may make his own special input circuits.

Other improvements in this new series include: extended frequency response, improved regulated power supply and stylus temperature control for each channel. Improved control of input signals by use of 1, 2, 5 ratios on attenuator. A selection of nine paper speeds is possible and is provided on one control from 0.25 to 100 mm per second.



Sanborn Co., Industrial Div., 195 Massachusetts Ave., Cambridge 39, Mass.

Variable Speed Drive with Built-in Brake Motor

For the first time, according to the manufacturers, a variable speed drive is available with built-in magnetic disk brake motor in the 42-48 frame. Never before has a drive with built-in brake motor been available in these small sizes. This new unit offers instant stops as frequently required for indexing tables, welding positioners, tensile and compression testers and the like.

This new brake, only 5 in. in dia and less than 3½ in. in length, mounts directly on the end of the motor giving a compact package of motor, brake, variable speed transmission and built-in reducer, all of which may be mounted with only four bolts.

Features of this new brake motor include an external manual release automatic reset mechanism, new friction elements which eliminate lining wear adjustments and replacements, and a brake enclosure applicable to both open or totally enclosed motors.

The transmission itself is also available without motor and can be had with a variety of built-in reductions, both spur and worm types, with output shaft extending horizontally or vertically. The transmission shown here is equipped with the standard micrometer control offering a straight line control which may be read accurately to 1/400 of the dial periphery. Remote mechanical, electrical or pneumatic control are also available.

Accurate control with exact speed holding and resetability

is possible at all speeds from maximum to zero and full reverse if desired. The transmission is a compact self-lubricated unit with a built-in overload protection in the event of an overload or a jam in the driven machine.

Graham Transmissions, Inc., Menomonee Falls, Wis.

CONTINUED ON PAGE 240

N·A·X
ALLOY STEELS

MODERN STEELS for MODERN TRANSPORTATION

- **N-A-X HIGH-TENSILE** steel—a low-alloy high strength structural steel used to reduce weight and increase life of your product.
- **N-A-X AC 9115** steel—for gas turbines and similar products requiring strength of material when operated at higher than normal temperatures up to 1000°F.
- **N-A-X 9100** series—alloy steels for carburizing and heat treated parts.

With these three N-A-X ALLOY STEELS, we offer time proven products to economically serve you.

N-A-X HIGH-TENSILE is 50% stronger than mild carbon steel with high notch toughness. Has excellent cold forming and welding properties and greater resistance to atmospheric corrosion and abrasion.

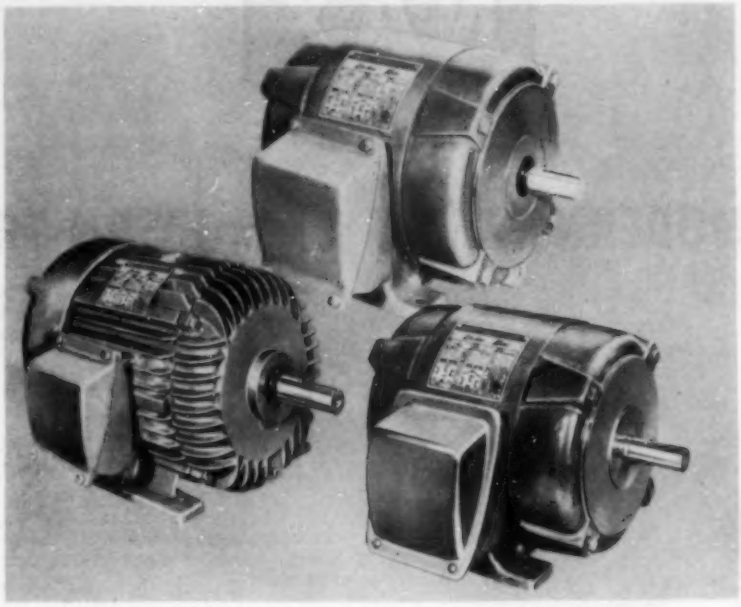
N-A-X AC 9115—a steel easily fabricated and welded by any method, maintains high strength at elevated temperatures up to 1000°F. When protected against high temperature oxidation by proper coatings, it is a worthy alternate for the higher-alloy stainless type steels for this application.

N-A-X 9100 series—a series of alloy steels with the alloying elements constant within an established range, with carbon varied to suit the hardenability and hardness desired. An outstanding carburizing steel.

GREAT LAKES STEEL CORPORATION
N-A-X Alloy Division Ecorse, Detroit 29, Mich.
NATIONAL STEEL CORPORATION

Induction Motor Has New Design Features

Designed to offer longer motor life, greater flexibility in application, and higher reliability as well as decreased size, a new induction motor, called the Life Line-A, has improved ventilation, better insulation, a more efficient and better protected bearing and in addition, is quieter and smaller per horsepower than previous models. These additions conform to the new NEMA standard dimensions. The motor is available in three enclosures: totally enclosed fan cooled; totally enclosed non-ventilated; and dripproof; as shown from left to right in the illustration.



The wire insulation is a synthetic resin that is said to have a life of over three times that of other wire insulations. The cable insulation, a lacquered glass braid covering, has an operating temperature of 75 C compared to 60 C for previously used cable insulation.

The ventilation system on the dripproof motor now permits the motor to be used for both indoor and outdoor applications and places where a totally enclosed motor is not required. The ventilation system is a straight through design with the ventilation openings located in one quadrant of the rim of the end bracket, protecting the motor from overhead drippings. The splashproof enclosure has been eliminated. The blower fan on the totally enclosed fan-cooled motor is made of molded glass plastic.

The motor has a four way bearing seal, with two seals on each side of the bearing—an inner seal and an outer seal. The inner seal is stationary and is attached to the outer bearing race. The outer seal rotates and is attached to the inner bearing race. The totally enclosed motors, which are subjected to corrosive atmospheres, are equipped with a bearing by-pass that prevents the motor from breathing through the bearing by equalizing the pressure on each side of the bearing. This by-pass in coordination with an external seal stops contaminants from entering the bearing grease and the motor itself.

The frames of all the motors are of cast iron. In conforming to the new NEMA standards for dimensions of motor from 1 to 30 hp, the new motors are smaller per horsepower, but with no detrimental effect on their electrical characteristics. They were designed with attention to good running torques at all speeds. The sheet steel in the motors has been reduced by 15 percent, but due to the use of silicon steels, electrical losses have been reduced by 20 percent.

The new motor is quieter in operation than the old model. The manufacturer claims that it takes two new motors to create the same sound level in a quiet room as did one of its predecessors. The sound level of the new motor is 50 to 55 decibels.

Westinghouse Electric Corp., Motor & Control Div., Buffalo, N. Y.

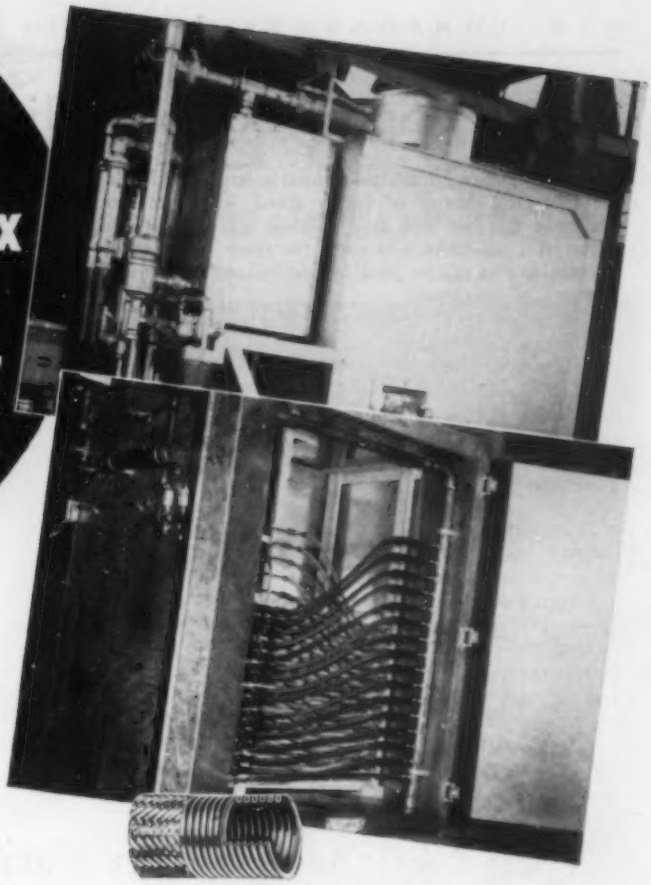
A MINIATURIZED SERIES OF PRESSURE SWITCHES suitable for all airborne pressure control applications is now available in any pressure range from 100 psi to 10,000 psi. The switch weighs about ¾ oz. and it has been designed around the newly developed B-tube pressure-sending element which is said to have a greater ability to withstand higher vibration and G-loads than the Bourdon tube. It is linear and inherently straight-line in operation. Miller-Robinson Co., 7007 Avalon Blvd., Los Angeles 3, Cal.

UP TO 50 PERCENT LIGHTER than conventional types, a new coreless power resistor will find application where reduced size and weight is important. Made of a ceramic refractory material completely enclosing the wire windings, this construction permits the use of finer wires for applications requiring higher than standard ohmic values, and closer resistance tolerances. The coating is a non-organic vitreous enamel to take the higher temperature of characteristic V of MIL R26B. General Electric Co., Syracuse, N. Y.

ENVIRONMENT-PROJECTED, precision wire-wound resistors called N-CAPS, are encapsulated in a hermetically sealed, plastic jacket which protects them against the effects of salt water as well as ordinary mechanical shock. They are made to exceed specification MIL-R-93A, and due to the encapsulating process, retain their original characteristics over a long period. The following Government sizes are available: RB 15, 16, 17, 18, 19 and RB 52 series. Eastern Precision Resistor Corp., Richmond Hill 18, New York.

CONTINUED ON PAGE 242

NOW
INDUSTRIAL REX-FLEX
Heavy Wall
Stainless Steel
HOSE



Available in four types to meet every design need

TYPE RF-44—Annularly corrugated; sizes from 2½" through 6" I.D. for working pressures to 40 psi.

TYPE RF-45—Same as Type RF-44, but with metal braid covering for working pressures to 410 psi.

TYPE RF-54—Helically corrugated; sizes from ¼" through 2", I.D. for working pressures to 440 psi.

TYPE RF-55—Same as Type RF-54, but with metal braid covering for working pressures to 3100 psi.

To meet the growing demand for heavy duty stainless steel hose, Flexonics Corporation now offers new heavy wall Industrial REX-FLEX. Backed by unmatched experience in the manufacture of corrugated stainless steel, steel and bronze hose, the new Industrial REX-FLEX marks an important step forward in the development of corrosion-resistant hose that can stand the gaff of rugged industrial service, and still maintain maximum flexibility.

A complete range of flanged or screwed fittings may be used, attachment being made by silver brazing or atomic hydrogen welding.

Write for data sheets on Industrial REX-FLEX. For specific recommendations send an outline of your requirements.

TYPICAL APPLICATIONS FOR INDUSTRIAL REX-FLEX

- *Weigh tank connections*
- *Superheated steam*
- *Conveying corrosive gases and liquids*
- *High temperature connections*
- *Vibration connections*
- *Vacuum hose*
- *Fireproof connections*
- *Conduit*
- *Offset motions*
- *Continuous flexations*
- *Air ducts*
- *Exhaust connections, etc.*

WRITE FOR CATALOG

Industrial REX-FLEX is part of Flexonics' complete line of flexible metal hose. Other types are described in Catalog 132. Or see the Flexonics catalog in Sweet's File for Product Designers.

Flexonics *Corporation*

CHICAGO METAL HOSE DIVISION
1351 S. THIRD AVENUE · MAYWOOD, ILLINOIS

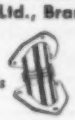
FORMERLY CHICAGO METAL HOSE CORPORATION
In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ontario

Flexon identifies products of Flexonics Corporation that have served industry for over 52 years.

Flexible metal hose

Expansion joints

Aircraft components



Metallic bellows

Rotary Speed Control Adjustable to Any Speed

A new mechanical electric translator has been developed for automatic control of rotary speed, with two models available: the first will open or close any desired electric circuit at a predetermined rpm; the other is a multispeed instrument that can be used for the automatic control of a sequence of operations.

This translator is readily adapted to a wide variety of functions involving automatic control of rpm. Only 2½ in. in dia by 4½ in. high, the instrument fits a standard Army-Navy mounting pad, is built to exacting military specifications.

Originally designed as an rpm control switch to prevent overspeeding of aircraft engines and helicopter rotors, the device also has a wide field of military and industrial applications.

Features are its ability to operate when mounted in any position, and the ease with which it can be adjusted to operate at any desired rpm.

The operational range of the instrument is 1,200 to 5,000 rpm, and its accuracy is plus or minus 2 percent. According to the manufacturer, industrial control applications include the fields of bottling, food processing and canning, and a variety of assembly-line applications.

Kahn & Co., Inc., 541 Windsor St., Hartford 1, Conn.

Cam Clutches Used in Variety of Machine Drives

A new line of cam-type, one-way clutch units, see illustration, designed to serve as backstop (anti-rotation), indexing and overrunning clutches in a wide variety of machine drives is made with OD dimensions and tolerances corresponding to seven sizes of standard 200 series ball bearings. The clutches have no inner race; the full complement of cams bear directly on a hardened shaft surface. Thus, individual clutch units can be mounted in a machine housing bore adjacent to the ball bearing supporting the shaft on which the clutch acts.

When applied as a backstop or anti-rotation unit in a machine drive, the outer race of the clutch is keyed in the housing bore. The shaft on which the cams bear can rotate or "free wheel" in one direction only.

In backstop applications, the clutch unit is usually installed on a high speed, low torque shaft of a power drive train or the output shaft of the speed reducer powering the drive train. Typical machinery applications of this type include speed reducers, speed changers, gear motors, variable speed drives and power drives in all types of industrial equipment such as conveyors, materials handling equipment, hoist, winches, and pump systems.

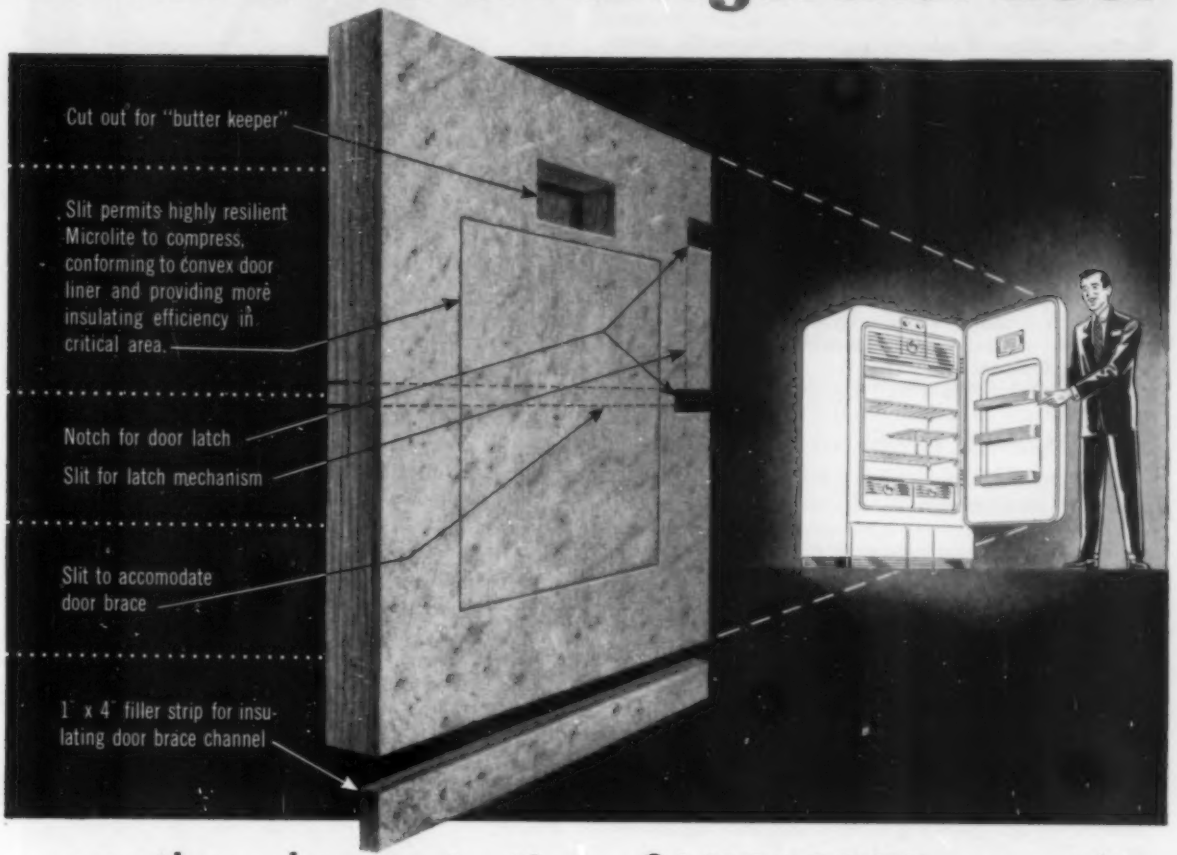
These new 200 series cam clutches are made in seven standard sizes to fit series 203, 4, 5, 6, 7, 8 and 10 ball bearing housing bores having nominal diameters from 1½ in. to 3½ in. Outside diameters of shafts at the clutch bearing area are from 0.650 in. to 2.209 in. Lengths of the clutch units are from 1 in. to 1¼ in. Free wheeling of shafts at speeds up to approximately 2,000 rpm can be achieved without excessive temperature rise in the clutches.

When used as a backstop unit, the clutches have torque ratings of 30, 40, 65, 150, 240, 350 and 500 ft-lb. These torque ratings are on a basis of an allowable contact stress of 504,000 psi. Torque ratings of the units for indexing applications vary from 10 to 165 ft-lb with allowable contact stress of 300,000 psi. As overrunning clutches the units have torque ratings from 20 to 330 ft-lb with allowable contact stress of 420,000 pounds per square inch.

Morse Chain Co., 7601 Central Ave., Detroit 10, Mich.

CONTINUED ON PAGE 244

2 pieces...
instead of 15...
to insulate a refrigerator door


Cut out for "butter keeper"
Slit permits highly resilient Microlite to compress, conforming to convex door liner and providing more insulating efficiency in critical area.
Notch for door latch
Slit for latch mechanism
Slit to accomodate door brace
1" x 4" filler strip for insulating door brace channel

...another demonstration of MICROLITE versatility

Two pieces of Microlite, one of full door size, the other a simple filler strip—*instead of 15 pieces of another material.* Here is a convincing demonstration of those special characteristics of Microlite glass fiber insulating wool attributable to the Electronic-Extrusion process. *No other producer of glass fibers uses this process.*

The remarkable compressibility* and resilience of Microlite, its softness and "handle-ability", its feather-lightness, the facility with which it can be cut and shaped, its resistance to settling, its excellent "k" factor—all these characteristics, so fully exploited in this refrigerator door application, are made possible by the long, extremely uniform glass fibers flame-blown by Glass Fibers' exclusive process.

Whether you design and build refrigerators, deep freezers, air conditioning units or other insulated equipment, you should have our illustrated, descriptive folder on Microlite. Samples too. Write to Glass Fibers Inc., 1810 Madison Avenue, Toledo 2, Ohio.

• • •

**Further evidence of Microlite's compressibility: it comes to you in packages compressed 6-to-1, saving storage space.*

VITRON Glass Textile Yarns • Rovings • Micro-Fibers
DURAMAT Vapor Barriers • **BLUE FLAG** Pipe Wrap
MICROLITE Thermal and Acoustical Insulation
VIBRAGLASS Mounting and Packaging Materials
COUSTIC-AIRE and **THERMO-JET** Aircraft Insulations

GLASS FIBERS *INC.*

Makers of glass fibers by the ELECTRONIC-EXTRUSION process ... developed, patented and used exclusively by Glass Fibers Inc.

New Instrument for Low Amperage Measurement

The model 2008 decade shunt shown is an accessory for the electrometers made by this company. It clips easily over the input terminals of an electrometer, converting it to a wide-range microammeter. Typical uses include measurements of currents in micromicroammeter photocells, insulation leakage current and resistance, capacitance, and as a high-resistance decade box.

Twelve switch positions are provided on the decade shunt. The two end positions are short-circuit and open-circuit. The other ten carry resistors in decade values ranging from 10^3 up through 10^{12} ohms. The lower value resistors are accurate within 1 percent of nominal rating, and resistors above 10^7 ohms are within 2 percent of nominal. A chart on the back of the shunt gives values of the higher ratings within 1 percent.

The reciprocal of each resistance value is expressed on the dial as a current range; current is then read as the electrometer reading times the current range. For example, if the electrometer reads two volts on the 10^{-12} current range, the current is 2×10^{-12} amperes. This is the lowest current that can be measured full scale on a electrometer. Lower-scale readings as small as 5×10^{-14} amperes can be made.

The electrometers have many uses wherever a self contained d-c voltmeter with an extremely high input impedance is required. Present applications include measuring the voltage of charged capacitors, piezo-electric potentials, measurement of unusually high resistances, measuring d-c amplifier potentials and detection of electrostatic charges.

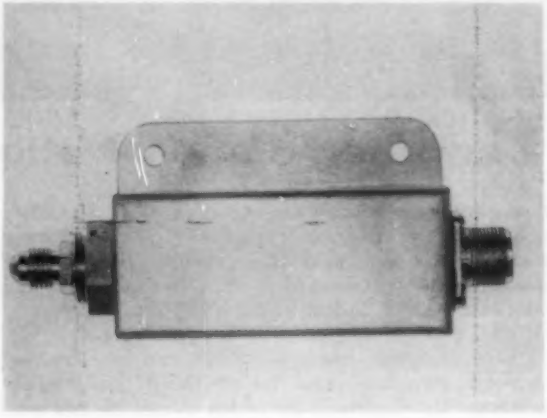
Keithley Instruments, 3868 *Carnegie Ave., Cleveland* 15, *Ohio*

Pressure Switch For 400 To 3,500 Psi

Operating over a range of pressures (hydraulic or pneumatic) from 400 psi to 3,500 psi, and an ambient temperature range of —65 F to plus 160 F, this new pressure switch employs a new principle that reduces its weight to eight ounces, and yet enables it to withstand bursting pressures up to 7,500 psi without leakage, loss of ability to recycle to its original setting, or damage to working parts.

Within working limits of 400 to 3,500 psi, the switch responds to a minimum differential of 200 psi. It is a single-pole double throw unit, normally closed, rated for 10 amps at 28 v d-c at 50,000 feet. Overall dimensions are 4.75 by 2 by 1.28 inches.

Adjustment of working pressure is easily made, and the normal operating differential of 250-to-300 psi is maintained over the entire range with only the slightest variation at the extremes of ambient temperature.



Prereg Mfg., Inc., 18 *Liberty St., Stamford, Conn.*

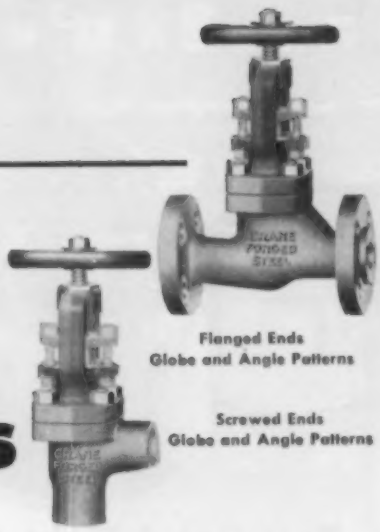
CURE TIME for a new electrical insulation resin, which comes in a two-part liquid form, is from two to four hours at 250 F, with a longer cure at lower temperatures. It has a useable life of from three to five days before setting up. Typical applications of the new material are for embedding resistors, unitized electronic circuits, pre-amps, torroids, and audio and power transformers—hermetically sealed—in a solid block of resin to provide trouble-free operation under adverse conditions. Good electrical characteristics include a dielectric strength of from 1,000 to 1,500 v per mill on thin sections. Minnesota Mining & Mfg. Co., 900 Fauquier St., St. Paul 6, Minn.

CONTINUED ON PAGE 246

unmatched in dependability

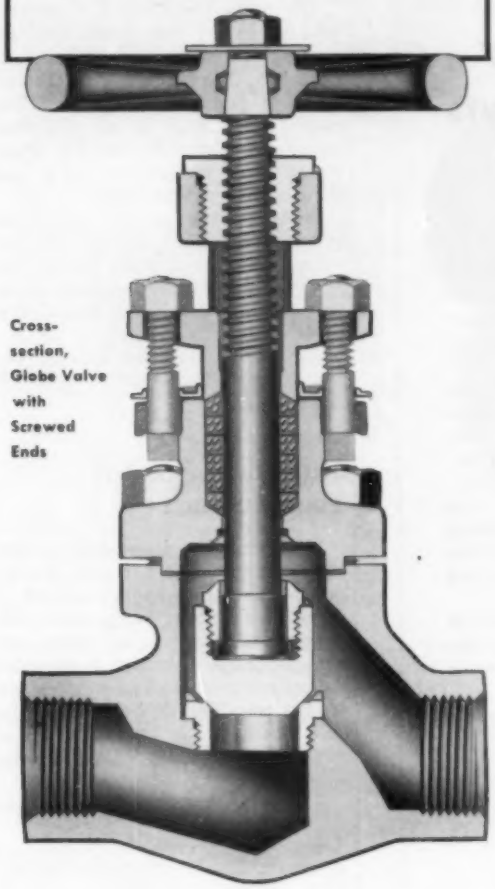
CRANE

chlorine valves



Flanged Ends
Globe and Angle Patterns

Screwed Ends
Globe and Angle Patterns



Cross-section, Globe Valve with Screwed Ends

now regularly available with screwed ends *and* flanged ends

Take your choice of patterns in these Crane chlorine valves. They're *Crane Quality* throughout—designed exclusively for water-free chlorine gas or liquid up to 300° F.

In the cross-section you can see their strong, rugged construction—and the narrow bearing 45° taper disc and seat design that provides positive closure. Corrosion-resistant materials are used at all critical points. Disc, body seat ring and disc stem ring are durable Hastelloy "C." The stem and the gasket at the leak-proof bonnet joint are Monel. In the extra deep stuffing box there's laminated packing specially developed for chlorine service.

You're better equipped for chlorine control with Crane chlorine valves. Sizes ½ to 2-inch.

FULL FACTS are in new 4-page folder AD 1976. Write direct or ask your Crane Representative next time he calls.

THE BETTER QUALITY... BIGGER VALUE LINE... IN BRASS, STEEL, IRON

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CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

You Get A Tight Grip on Quaiity and Costs With Townsend Locknuts

Quality and costs are controlled firmly when you use Townsend locknuts in product assembly. They are designed to apply positive pressure to keep bolted connections tight at all times even under severe vibration and shock. Lockwashers, double assembly and double inventory are eliminated for increased efficiency.

Through use of special organic inserts, Townsend locknuts grip the bolt securely—stay put under a variety of adverse conditions until removed with a wrench. Both inserts resist moisture, dryness, gasoline and lubricants.

The Townsend Nylok Nut* on the left is cold forged to provide added strength in the body and threads. The locking element in the nut is a tough nylon plug insert in one hex face which projects beyond the crest of the thread. When the nut is run down on a bolt, the highly resilient nylon is compressed but not cut by the bolt threads. Its spring-like action grips threads tightly and sets up a counter-thrust, creating strong metal-to-metal wedging of bolt and nut threads. When a Townsend Nylok Nut* is removed, the insert seeks to return to its original shape, giving great reusability. This also makes it possible to lock the nut in any position on the bolt—seating is unnecessary.

The Tufflok Nut* on the right is also cold forged in one piece for added strength in the body and threads. It has an exclusive petal design to assure staking of the hexagonal fibre insert. This provides a positive grip on the bolt at all times, since it cannot loosen or turn in its seat. Tufflok Nut* is an approved AN 365 part for use in aircraft.

Townsend locknuts are available in sizes #4 through ⅜ inch. For further information send the coupon below or write to us today.

*Licensed under the Nylok Corporation patents.
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Magnetic Positioning Tool

The magic positioner is a universal holding fixture for production and welding operations. It consists of three, 45 lb pull, neoprene covered alnico V permanent magnets. These magnets are held in an aluminum frame and have full 360 deg adjustment, which is regulated by a scale showing 5 deg graduations.

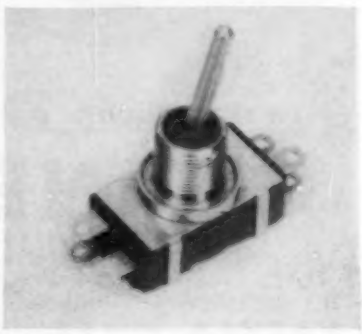
When positioned, each magnet can be locked in place. This feature provides for positioning the tool to conform to almost every welding operation, and the holding of almost every shape or design of metal.

Standard Portable Cord Co., Inc., 1939 Gibson St., Jamestown, N. Y.

Miniaturized Sealed Toggle Switch

Miniaturized and tested for a load of 10 amp at 250 v, a new double-pole, double-throw toggle switch is sealed in a bushing for panel mounting by means of a bonded silicone rubber diaphragm that has been tested statically without failure at a pressure of 240 psi. The diaphragm has also been tested up to 150,000 cycles of throw of the handle without leakage at 90 psi.

The switch has in its two-throw po-



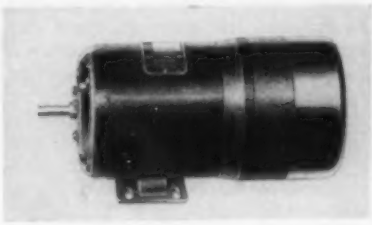
sitions a positive locking force between the contacts of 500 grams to prevent separation due to vibration.

The size of the switch is 0.625 x 0.407 x 1.140 inch. The sealed bushing has a $\frac{1}{8}\frac{3}{2}$ in. dia and is 0.420 in. high. A rubber O-ring is being used for a static seal against the chassis or panel.

Krautter-Weber Tool Co., 69-77 Twelfth Ave., Newark 3, N. J.

42 Frame Motor With Mounted Magnetic Brake

Now available for the first time, motors can be furnished in the NEMA 42 frame with motor mounted magnetic brakes. Both open and enclosed brake motors, single and three phase have been designed with either foot mounting or with NEMA type C face



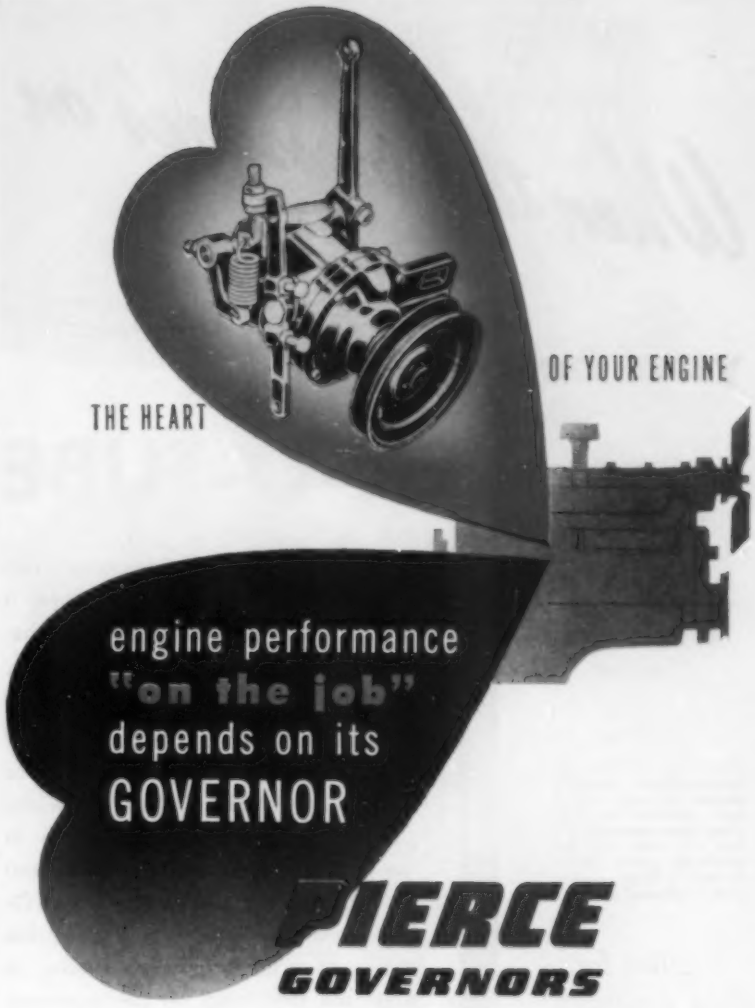
mounting. All motors are equipped with pre-lubricated ball bearings.

This line of motors incorporates the new 40 series brake; the maximum torque rating of the brake is 1 lb-ft, adjustable down to 6 in.-pounds. The brake is of the spring set, magnetically released solenoid type. The brake has an external manual release device and the brake enclosure is totally enclosed. Connections can be made either internally or externally.

Doerr Electric Corp., Cedarburg, Wis.

Universal Application Feature of Pulley-Type Governor

The new C-15 universal governor is applicable to practically all engines, according to the manufacturer. The extended actuating splined lever shaft makes it possible to shift the lever from one side to the other, or up and down, in a few moments time, for left or right hand mounting, and to line up properly with the carburetor lever. The cover may be rotated in any one of three positions, by removing the four cover screws, to conform to the



PIERCE GOVERNORS

offer you completely dependable governing plus all the advantages of Pierce's 40 years experience in solving design and engineering problems.

Pierce low-cost centrifugal governors are available for gas, gasoline or diesel engines . . . from small generator sets to monster power units. Send full details and specifications on your problem.

"WORLD'S MOST EXPERIENCED GOVERNOR MANUFACTURER"

the PIERCE GOVERNOR COMPANY INCORPORATED

1686 OHIO AVENUE
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When the pressure's on

your best bet is

FLEX-O-TUBE

Supplied in Assemblies

Flex-O-Tube will help you determine the assembly needed or work to your own specifications. In either case, modern facilities and latest inspection techniques assure you a uniformly high quality product delivered promptly.

Supplied for Field Assembly

Flex-O-Tube hose is also supplied in bulk coils with reusable fittings for field assembly. Complete range of sizes and types.

If you use flexible hose in your product or for replacement in your plant, it will pay you to specify Flex-O-Tube. For here is a name that has stood for finest quality and dependable service for more than a quarter of a century.

In the development of new uses for flexible hose, Flex-O-Tube provides you with dependable experience in the field. When used for replacement in industrial maintenance, Flex-O-Tube provides you with a complete range of products that are easy to assemble and long on performance.

Whatever your needs, why not discuss them with the local Flex-O-Tube field engineer. You'll find there are many good reasons why industry has relied on Flex-O-Tube for miles and miles of flexible hose products.

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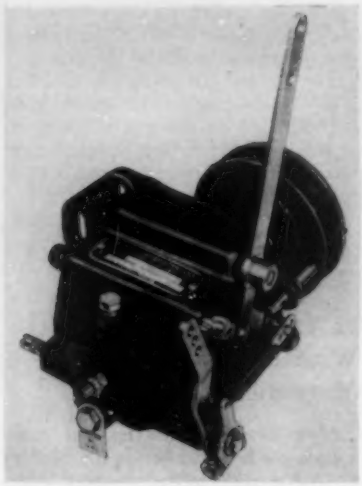


best possible position in relation to drive pulley and carburetor.

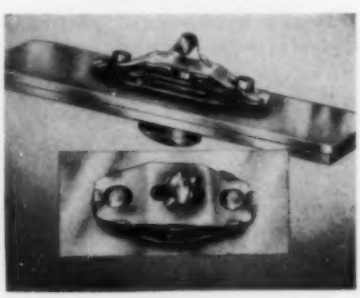
All of these new universal governors are furnished with variable speed levers. With a cable or rod attached to this lever, the governed speed may be varied according to requirements—particularly in case of operation through a power takeoff. The governor can be set for a definite operation and then, by means of a variable speed lever, the governor changes from such comparatively low speed operation to an engine rpm to take the truck over the road at a predetermined higher speed.

Hoof Products Co., 6453 S. Laramie Ave., Chicago 38, Ill.

Quick Locking And Opening Fastener

No larger than the standard No. 5 fastener, this quick-locking and opening fastener is a one-piece stud without cross pins, milled sections or holes. It locks with a quarter turn clockwise and unlocks in the opposite way. The unit is self-contained and remains intact. It cannot come apart.

Its strength characteristics are as follows: shear load 4,750 lb, (it cannot



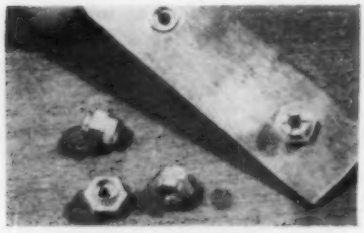
be overtorqued); tensile strength 3,000 lb; sheet separation 0.000; permanent set after load 0.000; lock torque, 8.5 in.; unlocking torque, 6.0 in., range of stud, 0.030; vibration resistance, vibrating at $\frac{1}{16}$ amplitude at 3,600 rpm.

The overall size of the fastener is 0.680 in. wide and 0.407 in. high. The spring assembly is only 1.490 in. long with 1 in. rivet centers. Stud has oval head $\frac{9}{16}$ in. in diameter.

Lion Fastener, Inc., Honeoye Falls, N. Y.

Locknut for Thin Section Material

An all metal clinch nut, also called a locknut is one of a complete line of fasteners now available for the electronics field. Included are regular locknuts, micro screws (down to size 0-80) and the larger flat-head, button-head, set and cap screws, and spring pins. The clinch locknut is a special



purpose fastener for mounting parts or assemblies on thin section material. Blind mounting is also made easier. It is cadmium plated, and can be used up to 550 S. Standard sizes are 4-40, 6-32, and 8-32, in the NC series, and 10-32, and $\frac{1}{4}$-28 in the NF series. Six different shank lengths range from 0.063 to 0.025 inches.

Standard Pressed Steel Co., Jenkintown, Pa.

Environment-Proof Aircraft Switch

A new series of environment-proof switches, designed for use in exposed locations in aircraft feature a hermetically sealed, split-contact switching unit enclosed in an aluminum housing. Their performance remains constant regardless of changes in atmospheric conditions. Also, they may be mounted near fuel tanks without danger of igniting escaping gases or liquids.

Six mounting holes in the housing are arranged to permit housing the switch from either side. Drain holes

NOW...the new CANNON AN-"E" PLUGS

ENVIRONMENT RESISTING

MEETS LATEST MILITARY SPECIFICATIONS

Streamlined Shell Approximately 25% lighter than previous design.

Stronger Coupling Nut Improved strength features.

New Grounding Lugs Integral; convenient.

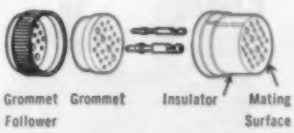
Integral Cable Clamp Space saving, fewer parts.

New, lighter polychloroprene . . . or Cannon's new exclusive premium Silcan 63, optional, featuring resilience, increased tensile strength, and long-lasting dimensional stability.

Closed-entry socket contacts, machined from solid high-conductivity copper alloys, silver-plated; hand tinned solder pots.

Telescoping Bushings Standard Equipment

AN3108E Plug mated with AN3102E Receptacle



No moisture condensation trap

The Cannon AN-"E" Connector grommet provides positive seal against the rear of the resilient insulator. Mating surfaces of resilient insulators of connectors are sealed by compressing the insulators 3/32" during mating. AN-"E" Connectors have **3 times the flashover** value of similar connectors, sealed. An important feature for high altitude and other applications.

Moisture proof! . . . Vibration resisting! . . . Resilient insulation!

Just what you've been waiting for! The new high-quality, streamlined, simpler, smaller, and lighter Cannon AN-"E" meets today's military specifications (MIL-C-5015A ASG) with improved connector performance. *Completely sealed from cable to cable.* A multi-service unit designed to meet your moisture condensation, flashover, corona, and vibration problems.

Write for "AN-E" Bulletin . . . TODAY!

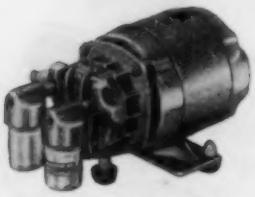
Refer to Dept. 106

CANNON ELECTRIC COMPANY, 3209 Humboldt St., Los Angeles 31, California. Factories in Los Angeles; East Haven; Toronto, Canada; and London, England. Representatives and distributors in all principal cities.

Since 1915 CANNON ELECTRIC

CANNON ELECTRIC

for original equipment vacuum pumps: call on GAST



Integral Motor-pump Model 0406 — To .6 CFM, 25" vacuum. Only 10-1/4" long, weight 16 lbs., 1/12 HP.

YOU GET HIGH QUALITY!

Gast Air Pumps solve many a product problem — with consistently high performance over a long service life. No accident, this results from simple, dependable rotary-vane design, plus rigid quality control in manufacturing. As reliable components, Gast Vacuum Pumps help "win friends" that bring repeat orders for your products.

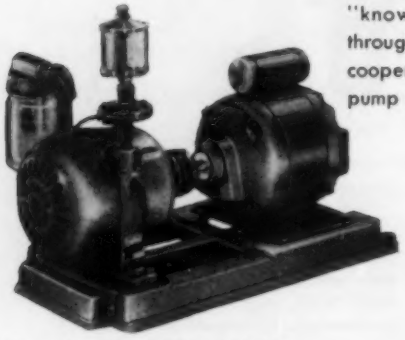
V-belt Model 1550-V2—To 10 CFM, 15" vacuum. Popular for paper feeding, vacuum back cameras, etc. Direct drive also.

A WIDE CHOICE OF SIZES—

Select the pump you need from five basic types — and many sizes — up to 24 CFM, or 28" vacuum. Many are offered with either standard or oil-less construction. Over 200 assembly models are in production — which helps lower your costs!

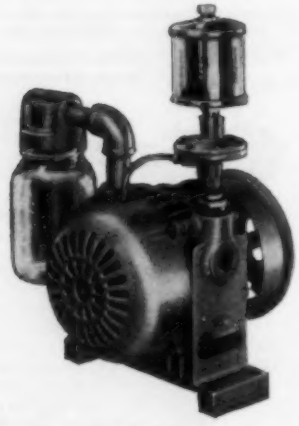
YOU GET FULL COOPERATION

Vacuum pumps for original equipment have been a principal Gast product for over 25 years. So you can tap a wealth of technical "know how" and valuable experience through Gast's engineers. They're ready to cooperate fully in solving your vacuum pump problems, so *call on Gast!*



Heavy-duty, Fan-cooled Model 1065-V4-34. To 28" vacuum with 1/2 HP. With or without base, motor.

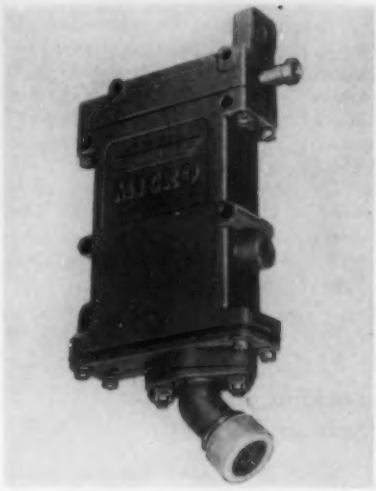
Some accessories standard equipment, others available for specific applications.



Heavy-duty, V-belt Model 2565-V-12A. To 28" vacuum, to 21 CFM. Two fans.

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY — AIR & VACUUM COMPRESSORS · VACUUM PUMPS
(TO 3 H.P.) (TO 30 LBS.) (TO 28 INCHES)
GAST MANUFACTURING CORP., 139 Hinkley St., Benton Harbor, Mich.



allow drainage of any moisture that might collect within the housing. The bottom plate of the housing is easily removed for wiring or replacement of the basic switching unit.

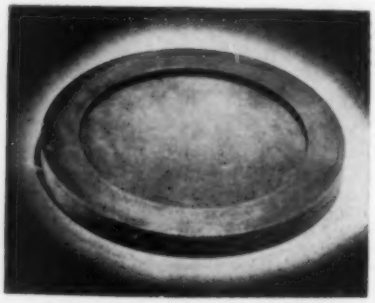
Typical of the series is the switch designated IEHI-Y, shown, which has overall dimensions of $6\frac{3}{4}$ by $3\frac{5}{8}$ by 1 inches. Operating force is nine pounds and the total plunger travel is $\frac{3}{8}$ inch. Four different conduit connectors are available.

Micro Switch, Freeport, Ill.

Expendable Graphite Rupture Disk for Pressure Systems

This impervious graphite rupture disk has been designed as an easily replaceable, expendable pressure relief device for protecting closed vessels and systems carrying highly corrosive fluids and gases. It is especially suitable for applications in the chemical, pharmaceutical, and petroleum processing industries.

The complete disk is machined to 0.002 tolerance from one solid piece of impervious graphite, which the manufacturer claims is immune to the



corrosive effects of most chemicals, features absolute zero porosity, and will not contaminate substances in process.

Capable of withstanding temperatures to 325 F, the rupture disks utilize the entire inside diameter of the vent line for the actual pressure relief membrane. They will fit any standard 150 lb flange and are intended to be used between vessel nozzle and vent line. Rupture disks are available for pressures from null vacuum to 75 psi, and in nozzle diameters from 2 to 24 in.

Falls Industries, Inc., 21829 Aurora Rd., Solon, Ohio

Miniature Permanent-Magnet Generator

Rated for continuous duty with an output frequency of 20 cps and a maximum of 3 percent harmonic distortion, this new type 44A generator is recommended for instrument indicating and other similar applications. Voltage is linear with speed, and the

unit develops 33 v of 2-phase a-c at 4,500 rpm. Internal winding resistance is 30,000 ohms per phase.

Weighing a total of 8 oz, the type 44A is $1\frac{3}{4}$ in. in OD by $2\frac{1}{8}$ in. long, and has a $\frac{5}{32}$ in. shaft extending 0.340 in. The generator is pressure-sealed and has permanently-lubricated bearings.

Dalmotor Co., 1362 Clay St., Santa Clara, Calif.

Precision, Internal Thread Comparator

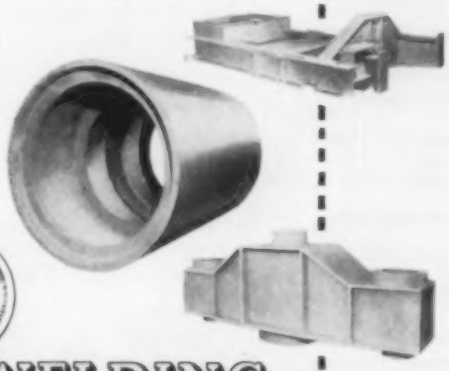
Designed for fast, accurate, economical visual gaging of all forms and classes of internal threads, in diameters ranging from $\frac{3}{8}$ to $1\frac{1}{2}$ in., threaded

NAVY CRANE RIDES HIGH on ACME Weldments

220 feet below the hook is quite a reach. When the Navy needed a portal crane that big to swing heavy sections on to vessels under construction, the Derrick & Hoist Corporation of Long Island City designed and built a diesel-electric giant with the right reach and a capacity of 50 long tons. *Carrying this big load are all-welded components fabricated by Acme Welding.*

ACME weldments were chosen in place of castings to assure *greater strength, rigidity,* and complete absence of flaws . . . to eliminate pattern cost . . . to provide greater design flexibility. If these advantages of welded fabrication are important to your product —especially when combined with exact adherence to your specifications—why not investigate Acme weldments *today*.

Send us your blueprints for a prompt quotation and ask for our informative booklet, "The FACTS about WELDMENTS and CASTINGS."



Acme WELDING

DIVISION of THE UNITED TOOL & DIE CO.

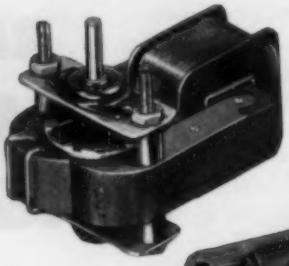
1064 New Britain Ave. • West Hartford 10, Conn.

National Representative TRANSMISSION EQUIPMENT CO., Inc. 441 LEXINGTON AVE., NEW YORK 17, N. Y.

QUALITY-ENGINEERED
Small Motors

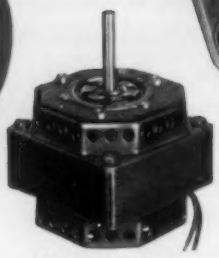
(1/60th to 1/500th H. P.)

Model A—2-pole A.C. Induction Type



Model C—2-pole A.C. Induction Type

Model O—2-pole Capacitor Type (for 6 or 12 or 24 volt A.C. only)



Model D—4-pole, 4-coil, A.C. Induction Type

FOR USE IN..

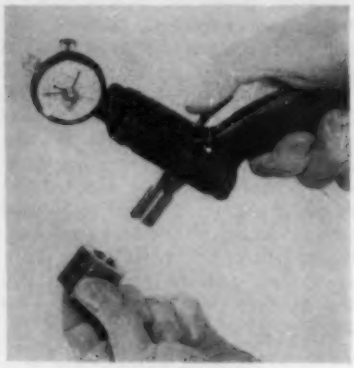
- Ventilating Fans
- Dictating Machines
- Room Circulators
- Recording Instruments
- Centrifugal Pumps
- Remote Tuners
- Bathroom Heaters
- Vending Machines
- Animated Signs
- Automati: Record Changers

From drawing board to final assembly line, General Industries *Smooth Power* Small Motors are quality-engineered to provide years of dependable service in countless small-load applications, including those listed at left.

Proof: actual performance records of thousands of these compact power units in use where low original cost, low operating cost and low maintenance cost all are important factors.

Write for literature containing dimensions, specifications and electrical characteristics of these dependable small motors. Inquiries also invited for special small motors in large quantities to meet specific application requirements.

THE GENERAL INDUSTRIES CO.
DEPARTMENT MM • ELYRIA, OHIO



parts can be gaged at the inspectors' bench, beside the machine, or on the machine at the rate of 20 or more pieces per minute.

The new inspection tool indicator tells whether parts are oversize, undersize, tapered, or if accumulated lead and angle error are within established tolerances. Because of its easily read visual indicator design, the internal thread comparator provides the means for classifying tapped holes within very close limits.

All classes of fit, American Standard or Unified Threads, can be checked with all adjustment of the indicator tolerances hands. The need is eliminated for maintaining 3 or 4 no-go thread plug gages for each thread size. One thread segment is collapsible, permitting fast loading.

Whitney Chain Co., 237 Hamilton St., Hartford 2, Conn.

Self Oiling Powdered Steel Bushing

This new powered steel alloy bushing is heat treated and has sealed internal oil wells as an integral part of the bushing. These bushings are shipped to user with oil wells completely filled, and no external oiling

is required throughout the long life of the bushings. The structure of powdered metal automatically assures proper lubrication to the friction surfaces.

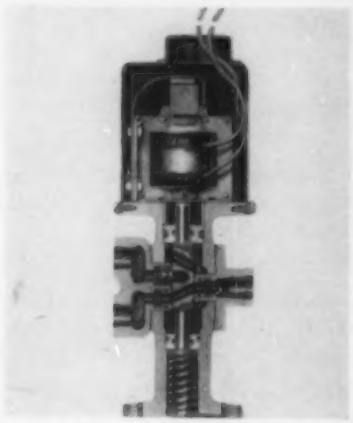
Overall wear characteristics are said to be comparable to bronze bushings, and guide pin wear is much less than can be obtained with any other type of bushing. Also, the new design reduces the possibility of seizing and galling guide pins.

According to the manufacturer, the new bushings—because of their self-oiling characteristics, their longer life, and their lower guide-pin wear—will offer the minimum maintenance, greatly reduced costs and the absolutely maximum press time.

Allied Products Corp., 1560 E. Milwaukee Ave., Detroit, Mich.

Solenoid Valves Are Wear Compensating

This new series of valves is designed for 0 to 250 psi oil service in industrial application. Incorporating the Shear-Seal principle, these valves are not critical to pipe scale or other foreign material in the liquid, because the lapped sealing members are in constant contact. The square corner wiping action of the shear-seal pushes dirt



aside and lets it flush out through the return port. No wire drawing, or scoring occurs, because flow is through the sealing members and never across the sealing surfaces.

Shear-seals are self-lapping and wear compensating; therefore, the sealing qualities of the valve improve with use. The valves are available in $\frac{1}{4}$, $\frac{3}{8}$, and $\frac{1}{2}$ in. pipe sizes in 4-way, 3-way and shut-off models for 110, 220, or 440 v, a-c.

Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif.

Keep in Step with—
STAINLESS TUBING USERS WHO KNOW!
SPECIFY "Standard"
for Welded Stainless Steel Tubing
Deal with the Specialist among Specialists
Stainless Tubing Size and Thickness
¼" O.D. to 4½" O.D.
.020 to .154 wall
Carbon Steel Tubing
½" O.D. to 5½" O.D.
.028 to .260 wall
THE STANDARD TUBE CO.
Detroit 28, Michigan
Welded Tubing
Fabricated Parts
STANDARDIZE with STANDARD — It Pays

ATLANTALLOY

PLASTER MOLD CASTINGS CAN SOLVE YOUR DESIGN PROBLEMS

Atlantalloy plaster mold precision castings provide non-ferrous castings *cast to ordinary machining tolerances*, effecting definite savings in machining and other costly operations. Atlantalloys are characterized by high strength, durability, and many other advantages.

NO. 10 YELLOW BRASS *Atlantalloy*	An all-purpose alloy for brush boxes, gears, levers, etc. Fine grain, clean, smooth surfaces assure tightness. Easily machined. Free from porosity. Fatigue resistant.	
NO. 20 ALUMINUM BRONZE *Atlantalloy*	Excellent for gears and bearings. Strong, light, zinc-free. Highly resistant to corrosion. Machines well.	
NO. 31 *High Tensile* MANGANESE BRONZE *Atlantalloy*	High strength engineering material for gears, valve bodies, electrical mechanisms, etc. Extremely durable. No heat treatment needed. Can be cast in thin sections.	
NO. 40 *High Strength* ALUMINUM *"Tenzalloy"*	Attains high strength through natural aging. Free from internal stress and skin hardness. Ideal for machining.	
NO. 60 ALUMINUM *Atlantalloy*	Perfect as instrument alloy. Fully uniform with no internal strain. Can be used for accurate, thin-sectioned castings.	
WRITE..	for free copy of "Quality Precision Castings for Industry." Get full data on our plaster mold process and alloys.	

ATLANTIC CASTING and ENGINEERING CORP.

Established 1937

721 Bloomfield Avenue • Clifton, N. J. • PRescott 9-2450

MEETINGS

April 12-15

SOCIETY OF AUTOMOTIVE ENGINEERS—National Aeronautic Meeting, Hotel Statler, New York, N. Y.

April 14-16

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS—Spring Meeting, Netherlands Plaza Hotel, Cincinnati, Ohio.

April 15-16

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Southern Textile Conference, Georgia Institute of Technology, Atlanta, Ga.

April 20-21

AMERICAN ZINC INSTITUTE—Annual Meeting, Hotel Statler, St. Louis.

April 22-23

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS — Feedback Control Conference, Claridge Hotel, Atlantic City, N. J.

April 26-28

METAL POWDER ASSOCIATION—Annual Meeting and Show, Drake Hotel, Chicago, Ill.

April 26-30

AMERICAN SOCIETY OF TOOL ENGINEERS — Exposition and Annual Meeting, Convention Center, Philadelphia, Pa.

April 26-30

AMERICAN TEXTILE MACHINERY EXHIBITION — Auditorium, Atlantic City, N. J.

April 27-29

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Electronic Components Conference, Washington.

May 2-6

ELECTROCHEMICAL SOCIETY — Sessions on Electric Insulation and Electronics, LaSalle Hotel, Chicago, Ill.

May 3-14

BRITISH INDUSTRIES FAIR—Olympia and Earls Court, London, and Castle Bromwich, Birmingham, England.

May 4-7

AMERICAN WELDING SOCIETY — Spring Technical Meeting, Hotel Statler, Buffalo, N. Y.

Catalogs and Bulletins

Request additional information using postcards following page 224

(1) MAGNETIC BRAKES—Dings Brakes, Inc., Bulletin B-4000-B, 6 pp. Gives design and application features and advantages, principle of operation, construction and installation of self-adjusting direct acting a-c and d-c disk type magnetic brakes. Has no solenoid, no mechanical linkages, and is available for floor or motor mounting. Available in 1½, 3 and 5 ft-lb torque rating. Has illustrations, and gives specifications for all models.

(2) HYDRAULIC EQUIPMENT—John S. Barnes Corp., Catalog, 160 pp. Has important data on: gear pumps; piston pumps; roto-blade pumps; combination pumps; directional valves; pressure valves; orifice valves; cylinders; auxiliary structures; structure combination panels and units; printing press power units; press type hydraulic structures; and solenoids. Has complete information, including colored cross-section and cutaway views, line drawings and specifications of all subjects covered.

(3) MOTORS, GENERATORS — Century Electric Co., Catalog, 150 pp. Has all characteristics including hp, range, torque, starting current, control required, overload protection, enclosures, type of load, and other data on: selective speed drives; capacitor—single phase—induction motors; fhp motors; oil burner motors; squirrel cage, polyphase, induction motors; totally enclosed fan cooled motors; and other types. Has many illustrations.

(4) TWO-SPEED TRANSMISSION —Tel-E-Lect Products Co., Catalog 563, 4 pp. Information on a new transmission for side-mounted power take-off for heavy duty uses. Features:

Cramer TIME CONTROLLED FOR QUALITY

CRAMER PERCENTAGE TIMERS CONTROL OVEN TEMPERATURES FOR EXACTING FINISHES

Cramer Percentage Timers shown above take the guess work out of finishing in the especially designed furnaces at the Industrial Finishing Company, Hartford, Connecticut.

"These Cramer timers give us the flexibility and dependability necessary to maintain uniform heat at exacting temperatures, without variation or interruption, required for today's attractive and durable paint finishes" . . . says Mr. Fred Hillier, President.

These Cramer Percentage Timers automatically control "on time" for the infra-red strip heaters in the entry and exit ends of the furnace. By pulsating the heaters on a definite time cycle, the exacting temperature control desired is automatically achieved.

Cramer fully adjustable Percentage Timers are available for panel, surface, or portable mounting in a number of standard NEMA enclosures, with time ranges from 15 seconds to 24 hours.

If you have a problem where time is a factor in control or operation, the R. W. Cramer Company can help you. Write for complete information.

The easily adjustable PE Timer, at left, repeats its cycle continuously with accuracy within 1%.

SPECIALISTS IN TIME CONTROL

Cramer TIMING DEVICES

the R. W. CRAMER CO., INC.

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✓SAVE UP TO 40% SPACE!
✓EXTRA HIGH SAFETY FACTOR!
✓DEPENDABILITY . . . backed by 38 Years of Know-How!
CIRCULAR HEADS WITH TIE RODS
SQUARE HEADS WITH TIE RODS
T-J
T-J
T-J
SPACE SAVED
T-J SPACEMAKER . . . provides additional room for adjacent equipment without sacrificing strength.

Off shelf delivery all styles to 3" bore in increments of 1" to 12" stroke.

NEW (T-J)

Spacemaker
AIR CYLINDERS

Streamlined design of the new T-J Spacemaker *eliminates tie rods . . . saves up to 40% in mounting space!* It's performance-proved . . . *super rugged* with extra high safety factor . . . solid steel heads . . . heavy wall, precision honed, *hard chrome plated,* seamless steel body . . . leakproof cylinder head to body construction . . . heavy duty, hi-tensile, *hard chrome plated* piston rod.

Available with the new T-J Super Cushion Flexible Seals which insure positive cushion with automatic valve action for fast return stroke. Many standard sizes and styles . . . for pushing, pulling, lifting, clamping or control jobs. T-J dependability. Write for bulletin 454. The Tomkins-Johnson Co., Jackson, Mich.

(T-J) TOMKINS-JOHNSON
RIVITORS · AIR AND HYDRAULIC CYLINDERS · CUTTERS · CLINCHORS

push-pull shift control; heavy duty bearings; hardened gears and shifts. Specifications per 100 rpm: low, 0.67; high, 1.67; hp, 5.1.

(5) WASHERS — Joliet Wrought Washer Co., Catalog 54, 12 pp. Has illustrations and listings of all kinds of washers. Included are: standard wrought washers; special washers and finishes; machine screw washers; machinery bushing washers; malleable iron, beveled, lock washers; square washers; expansion plugs. Other data is: standards for plain washers; proposed standards for apparatus use; and weight and diameter chart.

(6) COLD-FLOW METAL PARTS —Camcar Screw & Mfg. Corp., Bulletin 600, 8 pp. Discusses the cold-flow process of producing metal parts. Parts feature: natural grain structure to increase tensile strength and eliminate fractures and stress points; close tolerances; uniformity; negligible waste; high speed production. Illustrations show parts made and grain structure. Available with the bulletin is a kit with two samples of the products made from this process.

(7) MECHANICAL SEALS—Crane Packing Co., Bulletin S-204-1, 12 pp. Gives complete data on: general purpose seals; automotive water pump seals; cartridge type high production unit seals; high pressure, hydraulically balanced seals; seals for corrosive high temperature services; and high speed closures. Has many cross-sectional and cutaway views of each type showing construction.

(8) DYNAMOMETERS — Eaton Mfg. Co., Bulletin DB-1, 16 pp. Detail on a complete line of liquid-cooled, absorption, motoring, universal and special-purpose dynamometers. Data pertains to construction of equipment, accessories and controls. Typical installations are detailed. Has many illustrations, engineering drawings, graphs and tables.

(9) PIPE & FIN COIL DATA BOOK—Rempe Co., Bulletin 1053-2M, 34 pp. Contains information for the design and calculation of pipe and fin coils, heat transfer coefficients for heating and cooling, factors for computing fin coil surfaces, recommended materials for heating or cooling, heat

DU PONT
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PRODUCT ENGINEERING NEWS

PROPERTY AND APPLICATION DATA ON THESE VERSATILE PLASTIC MATERIALS: DU PONT NYLON, "ALATHON," "TEFLON," "LUCITE."

NO. 2 — 1954

Speedometer Adapter Parts of Du Pont Nylon Are Tough, Provide Electrical Insulation

Modern styling with Du Pont "Lucite"

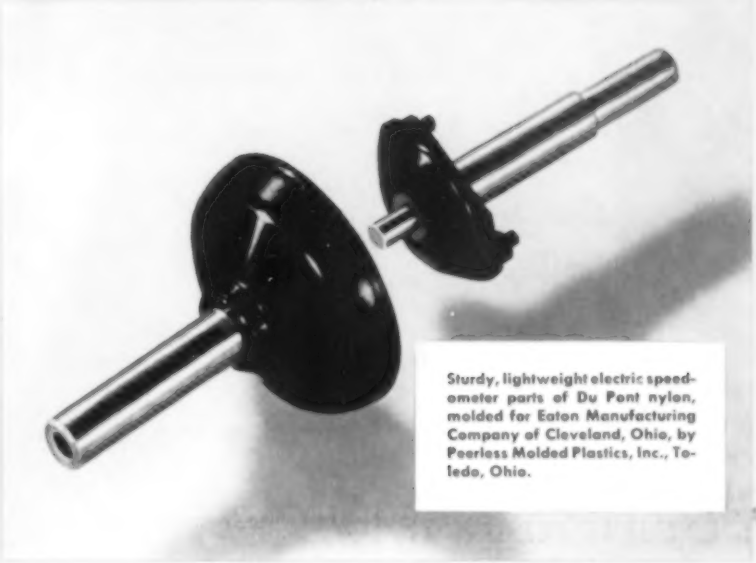
DU PONT "Lucite" acrylic resin has optical clarity, warmth to the touch, unique light-piping qualities, outdoor stability, and exceptional beauty—properties of tremendous potential to the designer. "Lucite" is readily molded into intricate shapes. It is lightweight, with a specific gravity of 1.18. Moisture resistance is excellent. These properties have provided

Lighting fixtures of Du Pont "Lucite" reduce glare and insure an even distribution of light.

an important medium for the designer. The illumination field has found wide use for "Lucite" because of its strength and ease of fabrication. Decorative items such as bowls and tableware can be formed of "Lucite," and are striking in appearance. Handles and strips of "Lucite" for household and office equipment add new beauty to a room and give long, satisfactory service.

Perhaps the wide variety of properties available with Du Pont "Lucite" can help blueprint your design ideas for the future. Clip the coupon, and send it to the Polychemicals Department of E. I. du Pont de Nemours & Co. (Inc.), for further information.

Accurate speeds, mileage for commercial trucks assured by parts of Du Pont nylon



Sturdy, lightweight electric speedometer parts of Du Pont nylon, molded for Eaton Manufacturing Company of Cleveland, Ohio, by Peerless Molded Plastics, Inc., Toledo, Ohio.

ENGINEERS at the Eaton Manufacturing Company have designed two key parts of Du Pont nylon for their new electric speedometer adapter. These Du Pont nylon parts have the properties that enable this adapter to operate accurately and dependably. They are lightweight; this reduces inertia forces so that the adapter responds quickly to speed changes of the axle. The abrasion resistance and outstanding bearing characteristics of nylon assure long-lasting, quiet operation, even without lubrication. Resilient nylon damps vibration. Operating temperatures (desert heat to sub-zero) encountered have no effect on the dependable performance of Du Pont nylon.

The good dielectric properties of Du Pont nylon were required for this application, because an insulating material was necessary to avoid interference with the electric shift mechanism.

These nylon parts are produced by injection molding. This process provides a part that's made to close tolerance—economically and rapidly.

OVER

DU PONT
REG. U.S. PAT. OFF.
Better Things for Better Living through Chemistry

PRODUCT ENGINEERING NEWS

PROPERTY AND APPLICATION DATA ON THESE VERSATILE PLASTIC MATERIALS: DU PONT NYLON, "ALATHON," "TEFLON," "LUCITE."

NO. 2 — 1954

Du Pont "Teflon" offers design flexibility

"TEFLON" tetrafluoroethylene resin has the following combination of thermal, electrical, and mechanical properties: **(1) Strength and Toughness** *retained at temperatures as low as −268°C (−450°F);* **(2) Heat Resistance** *permits continuous service at 250°C (480°F);* **(3) Chemically Inert** *to all solvents and chemicals normally encountered;* **(4) Zero Moisture-Absorption** *by A.S.T.M. test D-570-42;* **(5) Excellent Dielectric Properties** *over a wide temperature and frequency range;* **(6) Outdoor Durability** *. . . years of outdoor weathering do not affect the properties of "Teflon."*

Evaluate the properties of Du Pont "Teflon" for applications where special properties can provide special service.

Investigate Du Pont plastic engineering materials in your product development programs

ONE OF the family of these versatile engineering materials is often a key factor in product improvement or new product design.

The wide range of properties available with "Alathon"* polyethylene resin, "Lucite"* acrylic resin, "Teflon"* tetrafluoroethylene resin, and Du Pont nylon are helping solve industrial design problems in all industries.

NEED MORE INFORMATION?

CLIP THE COUPON for additional data on the properties and applications of Du Pont plastic engineering materials.

POINTERS ON PROCESSING OF DU PONT POLYMERS

How to make experimental parts of Du Pont nylon

PARTS for experimental purposes can often be machined of Du Pont nylon from standard shapes such as rod, strip, or cylinders. Nylon is readily machinable to close tolerances. In cutting, high-speed steel tools, ground for minimum drag, should be used. Coolants such as water and soluble oils allow higher cutting speeds. When working to close tolerances, make all measurements at room temperature.

Nylon can be sawed with regular band saws, jig saws, and table saws without modifications. Hollow-ground metal cutting blades placed in a conventional table saw will yield a smooth cut at high speeds. Again coolants are useful.

Nylon is drilled satisfactorily with ordinary twist drills. To obtain a smooth hole of uniform diameter, use a slow, uniform feed with the highest speed that will not cause "gumming" or burning. Keep holes chip-free by removing the drill from the hole frequently.

Expansion-type reamers are preferred for nylon, but it can also be reamed with the usual types. Cuts taken with a fixed reamer will tend to be undersized because of the resiliency of nylon. Remove at least 0.010 inch with the final ream to get a hole of the correct size.

Threading and tapping of nylon can be done with conventional equipment. A lubricant or coolant is useful for tapping and threading but isn't always required. A lathe and the usual single-point tool will cut threads in nylon, and successive cuts should be made as in metal. Finish cut should be no less than 0.005 inch.

Small parts machined from nylon rod. These parts are readily machinable to close tolerances.

For turning nylon, use bits with minimum drag. Nylon has exceptional abrasion resistance and resiliency, so finishing should be done with power-driven rotary steel burrs, abrasive disks or high-speed grinders.

Nylon can be cemented with a number of commercial adhesives.

The machined test parts should be stress relieved to insure dimensional stability. This is best accomplished by heating to 350°F in "Glycowax" or "Hitec" salt. In experimental work, where equipment is not available for high temperature stress relieving, boiling in water will be adequate in many cases. Close tolerances can be maintained with nylon, as with other engineering materials, by following the recommended procedures.

E. I. DU PONT DE NEMOURS & CO. (Inc.) POLYCHEMICALS DEPARTMENT
Room 104, Du Pont Bldg., Wilmington 98, Del.

Please send me more information on the Du Pont plastic engineering materials checked: ☐ *Du Pont Nylon* ☐ *"Alathon"* ☐ *"Teflon"* ☐ *"Lucite." I am interested in evaluating these materials for* _____

NAME _____ POSITION _____

COMPANY _____

STREET _____

CITY _____ STATE _____

TYPE OF BUSINESS _____

*"Alathon," "Lucite," "Teflon" are registered trade-marks of E. I. du Pont de Nemours & Co. (Inc.)

transfer factors and BTU load limitations. Has many illustrations and some specification data.

(10) AIR & HYDRAULIC CYLINDERS—Carter Controls, Inc., Bulletins 100A, 750, 1500, 12 pp. Has specifications for a line of air and hydraulic cylinders featuring maximum strength and easy maintenance. Head mount has 360 deg rotation. Hydraulic cylinders are in the 750 and 1500 psi class. Has many illustrations.

(11) PLASTIC PUMP — Vanton Pump & Equipment Co., Booklet, 4 pp. Illustrates and describes a line of flex-i-liner plastic pumps having neither stuffing box, shaft seals, gaskets nor internal valves, and designed to handle corrosive fluids and abrasive sluries. Has cut-away views, specifications, performance data.

(12) CIRCUITRY—Assembly Products, Inc., Bulletin 112, 8 pp. Explains the functioning of 11 control and alarm circuits using meter-relays. Described are: automatic reset, single contact; automatic reset, double contact; manual reset, double contact; self-releasing, both single and double contact; interlocked load relays; nonlocking contacts; plug-in units; and others. The principles of operation of meter-relays and some limitations on their use are discussed.

(13) FORGINGS, CASTINGS, DIE SECTIONS—Alleghany-Ludlum Steel Corp., Booklet FC4, 28 pp. Outlines the forged shapes available, stainless as well as tool steel, weight limits, and analyses. Also contains a guide to the uses and types of cast-to-shape tool steels. Chemical analyses and heat treating instructions are listed in detail. Information also on how to use and order composite die sections. Has many diagrams, cross-sections and charts.

(14) INDUSTRIAL CASTERS — Faultless Caster Corp., Catalog 157, 80 pp. Information to aid in the selection of casters designed and sized for specific duties. Has complete specifications for all types, with many illustrations of each.

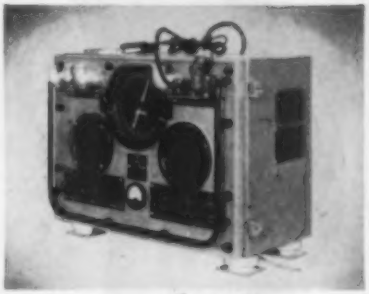
(15) PUMPING PROBLEMS—Geo. D. Roper Corp., Bulletin 3060, 36 pp. Called, "How to Solve Pumping

SHOCK - VIBRATION - NOISE

ISOLATION NOTES

DICTATING MACHINE FLOATS ON BARRYMOUNTS — For noiseless operation, smooth, faultless playback, and the ultimate in protection against vibration and shock, Soundscriber Corp. chooses Barrymounts to support their new transcription unit. One more instance of how Barrymounts protect the performance of precision instruments. *Ask for data on Type 372 Barrymounts.*

COAST GUARD DIRECTION FINDER GUARDED BY BARRYMOUNTS — Where reliability of performance is really vital, sensitive electronic equipment *must* be protected from shock and vibration. Raytheon Manufacturing Company says: "We find that the high quality and effectiveness of these mountings help us assure the famed reliability and excellence of our own products." *Ask for data on Type C-2000 Barrymounts.*



ALL-METL BARRYMOUNTS PROTECT AIRCRAFT RADIO COMPASS — For safe, assured, brilliant operation, at extremely high altitudes and over a wide range of temperatures, Lear uses Barry ALL-METL vibration isolators to support the sensitive components of their "Executive" radio compass. They say: "We have chosen the Barry product because we feel it is a superior product from the standpoint of providing greater trouble-free life". *Ask for data on Type M-44 Barrymounts.*

INDUSTRIAL MACHINERY MOBILIZED BY BARRYMOUNTS — For example: a production line of eight punch presses was shut down, moved 200 feet across the plant, and was producing parts again *in a total elapsed time of 23 minutes.* No lagging, no shimming, and no walking of the machines in operation — because they were mounted on the new Leveling Barrymounts. This is *machine-tool mobility* — a new idea to make new profits for YOU. *Ask for "LOOK — NO LAGGING!"*

The wide range of Barry products and the experience of Barry engineers can help you solve shock, vibration, and noise problems in any area of military or industrial activity. Call our nearby sales representative or write directly to us.

THE BARRY CORP.

730 PLEASANT ST., WATERTOWN 72, MASSACHUSETTS

SALES REPRESENTATIVES IN

Atlanta Baltimore Chicago Cleveland Dallas Dayton Detroit Kansas City
Los Angeles Minneapolis New York Philadelphia Phoenix Rochester
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MUELLER BRASS CO.

600 SERIES BEARING ALLOYS

FORGINGS • ROD • SCREW MACHINE PRODUCTS

proving their quality throughout American industry

Mueller Brass Co. "600" series bearing bronzes are lightweight, high strength copper-zinc base alloys with excellent bearing and mechanical properties, non-galling and non-seizing characteristics and good resistance to corrosion. They have a dense, homogeneous structure that reduces machining time and metal waste and increases tool life. As bearings, gears, connecting rods, cams and other parts, they will generally save you considerable money and outperform and outlast the cast phosphor bronzes. Write today for complete information about the MUELLER BRASS CO. "600" series alloys for forgings, rod or screw machine products.

six members of "600" series . . . one for every purpose

There are six members in the "600" series group, and they possess fundamentally similar characteristics. But slight differences in the properties of each are produced through variations in the basic formula. Thus, each metal is best suited to perform a specific set of functions. And as a group, they are suitable for a wide range of applications.

119

MUELLER BRASS CO. PORT HURON 17, MICHIGAN

Problems," it gives a general explanation of rotary gear pumps and factors of pumping problems. This part covers: the liquid to be handled; characteristics, conditions at inlet and outlet; pump selection; drives for rotary gear pumps; and driving power. Sample problems are given. Also discusses friction losses; viscosities of oils (includes conversion charts); specific gravity and temperature factors; and materials of pump construction. Has many illustrations, charts and curves.

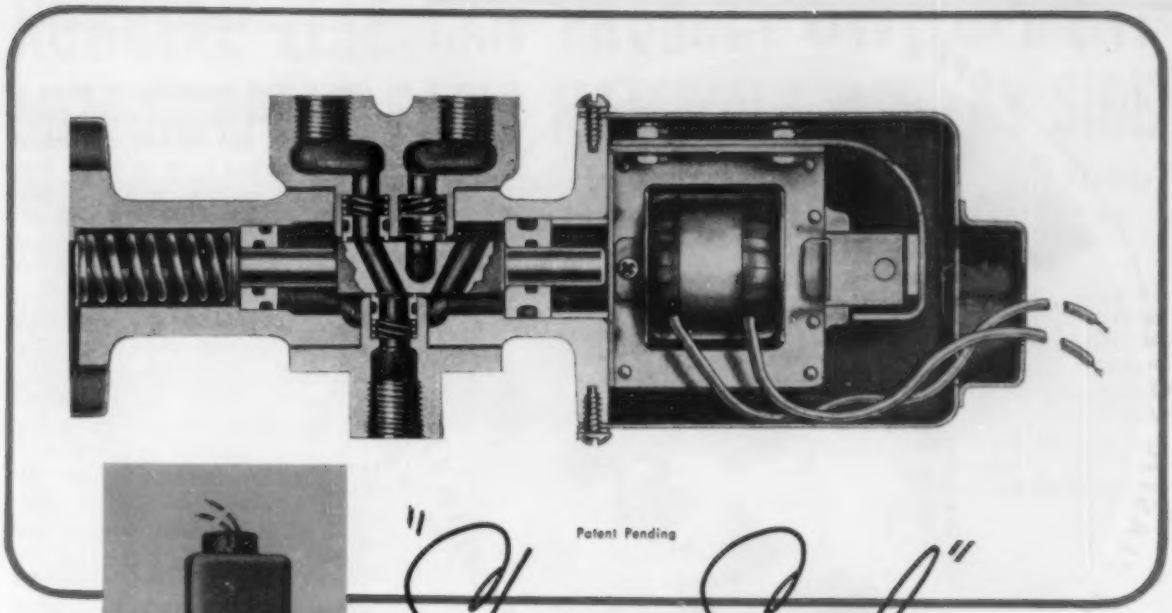
(16) REVOLVING JOINTS—Barco Mfg. Co., Catalog 300-B, 12 pp. Has information on a line of revolving joints recommended for all types of continuous rotation. Made in three styles: single flow; syphon; and revolving syphon. They carry steam, air, water, gas and chemicals. Has many line drawings and cross-sectional views, plus photos of typical applications.

(17) TEFLON PACKING & GASKETS — John Crane Co., Bulletin T-103-1, 12 pp. Lists various places where this material is used to advantage as a packing, a gasket, electronic insulation; and for non-stick uses. Illustrates and gives details on a line of: C-V rings; braided packings; gaskets; molded packings; extruded rod and tubing; molded forms and tapes; and bellows connectors.

(18) UNALLOYED TITANIUM—Mallory-Sharon Titanium Corp., Booklet, 4 pp. Gives properties of this material as a result of a new double melting process. Also contains recommended techniques for fabricating and forming titanium sheet. Sheets have the same characteristics throughout, and the carbon content can be controlled.

(19) WORM GEAR DRIVES — Link-Belt, Booklet 2324-A, 80 pp. Gives types and construction features; selection; hp ratings; overhung and thrust loads; outboard shafts and bearings dimensions; and worm gear drive applications. Has many illustrations of various models and where used. Phantom views show internal construction.

(20) HYDRAULIC POWER TRANSMISSION—Twin Disc Clutch Co., Bulletin 145-B, 14 pp. Informa-

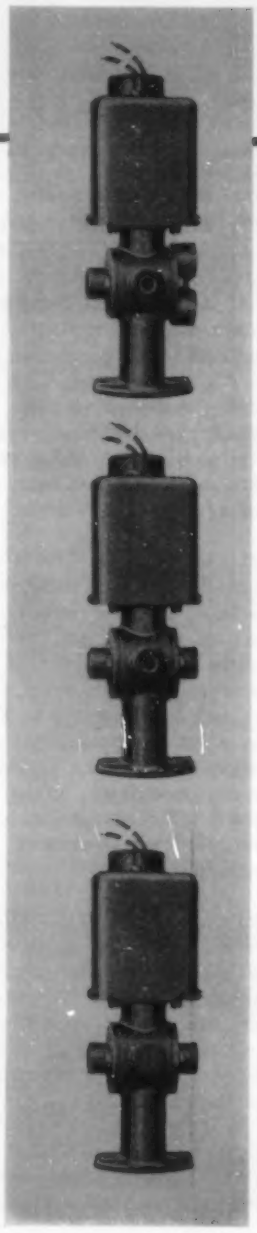


Patent Pending

"Shear-Seal"

SOLENOID VALVES

FOR 250 P.S.I. OIL SERVICE



FOUR-WAY

THREE-WAY

SHUT-OFF

Competitive in every respect! The patented "Shear-Seal" principle, that has changed the concepts of extreme pressure control, is now available in this popular edition.

If solenoid valves are among the components of your product, and it needs a sales point in place of a trouble spot, you should get complete data on Barksdale "Shear-Seal" Valves.

Leakproof closure is retained for unbelievably long periods without maintenance, because "Shear-Seals" improve with the lapping action of each valve operation.

Dirt or foreign matter can't harm the sealing quality, because the sealing surfaces remain in constant intimate contact, even during actuation, and flow is through the "Shear-Seal", never across sealing surfaces.

Long trouble free solenoid and valve performance are the end result of the many inherent "Shear-Seal" advantages, well worth your careful consideration.

Write for bulletin 4S.

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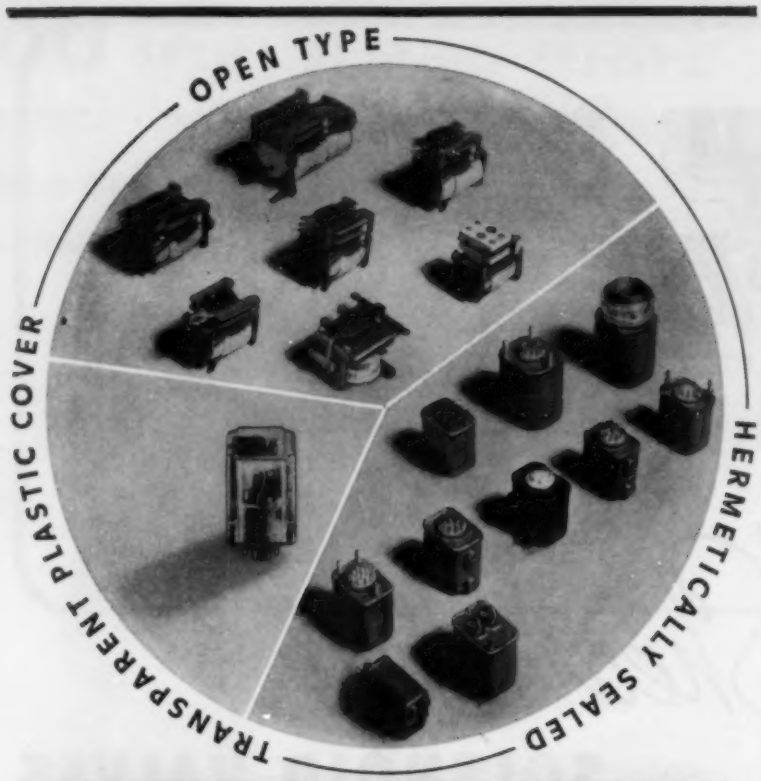

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Meeting Commercial and Government Requirements

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TRANSPARENT PLASTIC COVER. Most R-B-M relays now available in low cost transparent plastic cover.

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RBM **R-B-M DIVISION ESSEX WIRE CORP.**
Logansport, Indiana

MANUAL AND MAGNETIC ELECTRIC CONTROLS FOR AUTOMOTIVE, INDUSTRIAL, COMMUNICATION AND ELECTRONIC USE

tion on the Hydro-Sheave drive, a unit designed for application to electric motors and internal combustion engines in the ¾ to 50 hp range. Permits heavy loads to be started easily and accelerated rapidly. Has large colored cutaway view, photos showing application and operating curves.

(21) SELF-LOCKING FASTENER —Elastic Stop Nut Corp. of America, Catalog 800, 16 pp. Has engineering specifications for the rollpin, a slotted and chamfered cylindrical spring pin. It is compressed as it is driven into a hole, exerting pressure against the sides to prevent loosening by vibration. Charts list sizes available and various dimensions of pins; recommended hole tolerances; removal forces; and illustrations of applications.

(22) ELECTRICAL INSULATING MATERIALS — Insulation Manufacturers Corp., Catalog, 32 pp. Has complete technical data, descriptions and information on applications, sizes, stocks and uses of silicone materials for high temperature Class H electrical insulation. Covers silicone treated: glass cloth plastics; mica products; glass tubings and sleeves; glass cloth and tape; glass cord; and varnishes, adhesives and grease.

(23) MERCURY SWITCHES — Micro Switch Co., Catalog 90, 12 pp. Contains complete information and electrical ratings and specifications on the following types of mercury switches: protected; heavy duty; general use; small; sensitive. Each type has a list of applications and illustrations are given. Technical data covers: mounting; contact arrangements; differential angle; tilting action; lead wires; electrical capacity; and adjustment.

(24) MOLDED COIL RELAYS — Davis Electric Co., Catalog, 8 pp. Lists complete technical data regarding the various molded coil type open relays, hermetically sealed cannister type relays, and television deflection yokes. Covers operating characteristics, range and sensitivity.

(25) RIGHT ANGLE SLOW SPEED DRIVES—Foote Bros. Gear & Machine Corp., Bulletin LWA, 20 pp.

NOWHERE ELSE CAN PRODUCT DEVELOPMENT MEN COMPARE BASIC MATERIALS SIDE BY SIDE

More than 8,000 product development men from all branches of industry attended the 1st Basic Materials Exposition held in New York, last June. Enthusiasm for the exhibits and the ideas presented ran high.

2nd Basic Materials Exposition Offers Product Engineers Only Opportunity To Examine All Materials In One Place

Now product development men have an exposition all their own—the Basic Materials Exposition to be held in Chicago, May 17-20, 1954 at the International Amphitheatre. This new concept in expositions hits at the heart of the problems of the research and development engineer, and the marketing and merchandising executive.

It presents all the available materials and basic product components in one place for easy, side-by-side comparison.

HOW BASIC IS BASIC?

In clarifying the meaning of the Exposition to research and development people, Clapp & Poliak, Inc., producers of the Exposition, said, "We define *basic materials* as the *things* from which *things* are made. They include metals and alloys; plastics; non-metallic materials; coatings, finishes; fabricated parts and forms; and basic components."

The Basic Materials Exposition is a scientific showcase for materials only. It excludes the processing and production machines that so often overshadow materials.

WIDE RANGE OF EXHIBITORS

Scores of leading producers of basic materials and basic product components are planning to exhibit. Their products cover the range of materials from textiles to laminated wood; metal alloys to thermoplastics; metal forms to ceramics and glass, to name a few. Great interest is being taken by government agencies who view the Exposition as an opportunity to broaden the range of materials being used in various defense projects and in atomic energy installations.

Survey Shows 77% Of Engineers Found "Something New"

Seventy seven percent of the engineers in attendance at the 1st Basic Materials Exposition found something new, *not previously used* in their company's products which they will now consider or use; and found *new applications* for materials now being used, an independent survey on attendance reaction revealed.

Twenty nine percent* said they had discovered new uses for materials formerly rejected.

These discoveries show that the design and materials engineers who attended the 1st Basic Materials Exposition *found what they were looking for*. And, it can be expected that attendance at the Basic Materials Exposition in Chicago this Spring will be equally rewarding.

*Totals more than 100% because respondents answered more than one question.

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BASIC MATERIALS CONFERENCE PROMISES RESEARCH AND DEVELOPMENT GUIDANCE

Concurrent with the Basic Materials Exposition will be the 2nd Basic Materials Conference. Headed by T. C. Dumond, editor of Materials and Methods, this year's conference will be patterned around the most asked-for subjects at the past conference. These subjects cover a wide range of materials and materials applications. While the names of panel speakers have not yet been released, the following tentative program is an excellent indication of the worthwhileness of this conference to you and your company.

Monday, May 17

a.m. Review of New Materials Developments.

a.m. Rockets and Guided Missiles— How New Materials for Them will Benefit Industry.

p.m. Erosion and Corrosion —How to Combat Them

Tuesday, May 18

a.m. The New Metal Forming Processes—How, When, and Where to Use Them—
- Shell Molding
- Powder Metallurgy
- Investment Casting
- Impacting
- Extruding

p.m. How, When and Where to Use Nonmetallic Materials
- Plastics
- Carbon and Graphite
- Glass and Ceramics
- Rubber

Wednesday, May 19

a.m. Adhesives and Adhesive Bonding of Metals and Plastics

p.m. How to Set Up and Operate A Materials Department.

International Amphitheatre
Chicago, May 17-20, 1954

BASIC MATERIALS EXPOSITION

The Product Development Show

YES! *I would like to attend the Basic Materials Exposition and Conference.*

☐ Send me expedited registration tickets for the Exposition. No registration fee.

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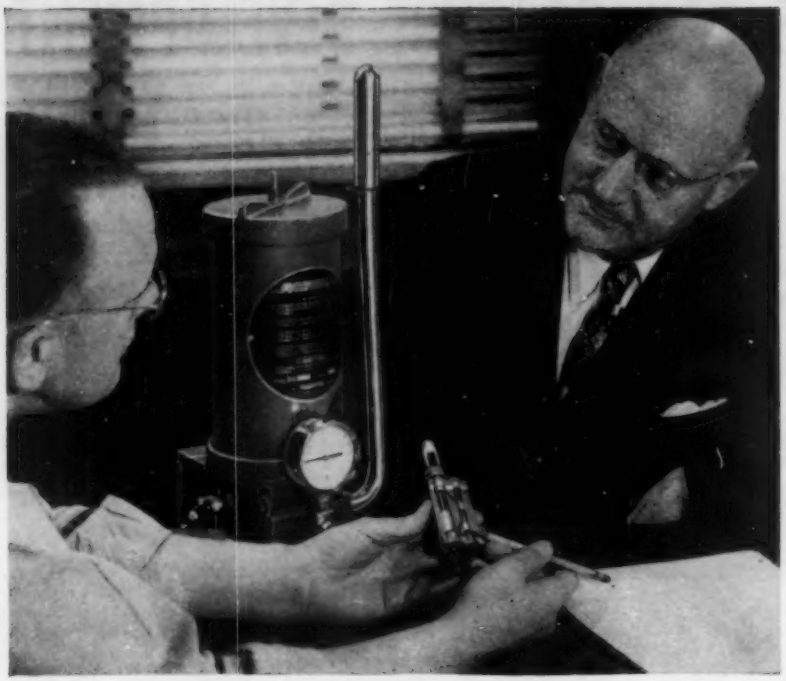


THE SUPERINTENDENT REPORTS TO THE GENERAL MANAGER

"Thanks to Farval, we're 375,938 hours ahead!"

IN a Detroit manufacturing plant, oiling machinery by hand took 11 men, or 27,456 man hours per year. In 1937 management installed 133 Farval systems to serve the 3100 bearings on its metal-forming presses.

Except for re-filling reservoirs, Farval completely eliminated the "human element" and over 15 years has saved the company 375,938 man hours—valued at $537,591 at prevailing labor rates.

In addition, the foreman reports not one shutdown for bearing replacement or repair due to faulty lubrication.

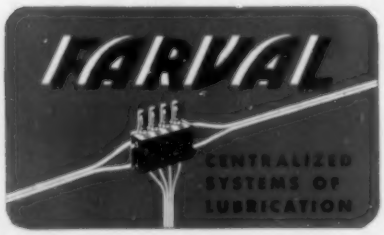
Farval is the Dualine system of centralized lubrication that hydraulically delivers oil or grease to each individual bearing, exactly measured, as often as desired. Today Farval systems protect millions of industrial bearings throughout the world.

FREE LUBRICATION SURVEY—Without obligation, let us send one of our expert lubrication engineers to inspect your plant equipment. He'll present recommendations in writing to show how Farval can save you money. Just mail coupon below or write us a note.

KEYS TO ADEQUATE LUBRICATION—Wherever you see the sign of Farval—the familiar valve manifolds, dual lubricant lines and central pumping station—you know a machine is being properly lubricated.

Above: Some of the Farvalized presses in operation. At top, superintendent demonstrates action of Farval valve with cutaway section. This valve has only two moving parts, is individually adjusted to deliver any desired amount of oil or grease to the bearing.

Farval is an affiliate of The Cleveland Worm & Gear Co. Manufacturers of industrial worm gearing.



The Farval Corporation, 3279 East 80th Street, Cleveland 4, Ohio

Send Farval Bulletin 25 and details of your free lubrication survey.

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Catalogs and Bulletins.....continued

Has data on both horizontal and vertical, foot and flange mounted. Has cutaway views showing internal construction and a selection guide. Rating tables are given based on various rpm, along with overhung load calculations.

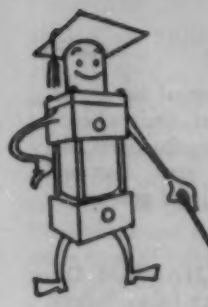
(26) ROTARY STEPPING SWITCHES—Automatic Electric Co., Bulletin 1698-C, 6 pp. Has specifications for a miniature rotary stepping switch that accommodates up to 6 bank levels with 10 points, and a larger rotary stepping switch for a-c and d-c use with 10 or more bank levels with 25 points. Has illustrations, performance charts and all engineering data.

(27) POWER TAKE-OFFS — Funk Aircraft Co., Catalog 111, 20 pp. Describes a line of standard direct power take-offs and gear reduction power take-offs built to SAE standard dimensions. Available in four clutch housing sizes: nos. 5, 4, 3 and 2. Direct power take-offs have three basic load capacity bearing hub and shaft arrangements: extra heavy, heavy and light. Has illustrations and specifications for all types.

(28) PRODUCTIMETERS—Durant Mfg. Co., Catalog, 60 pp. Contains complete descriptions and specifications on a line of counting devices. Types of counters covered are: stroke; rotary; Y small stroke and rotary counters; lineal; wire measuring; predetermined; bottle, can and case; electric and photo electric; tachometers; hard and desk tallies; and printing counters. Installation views of several are included.

(29) SPRING HANDBOOK—Accurate Spring Mfg. Co., Handbook, 40 pp. Contains much usable data and information. The sections are: spring design, round wire extension and compression; design formulation, helical springs and compression springs; designing round wire torsion springs; load deflection tables; conversion formulae for types of ends; how to specify compression, extension and torsion springs; and determining spring weight. Has many line drawings and other illustrations.

(30) GEARS — Automotive Gear Works, Inc., Catalog, 40 pp. Illustrates and gives information on the major types of gear available. Those



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FLUID PRESSURE BOOSTERS

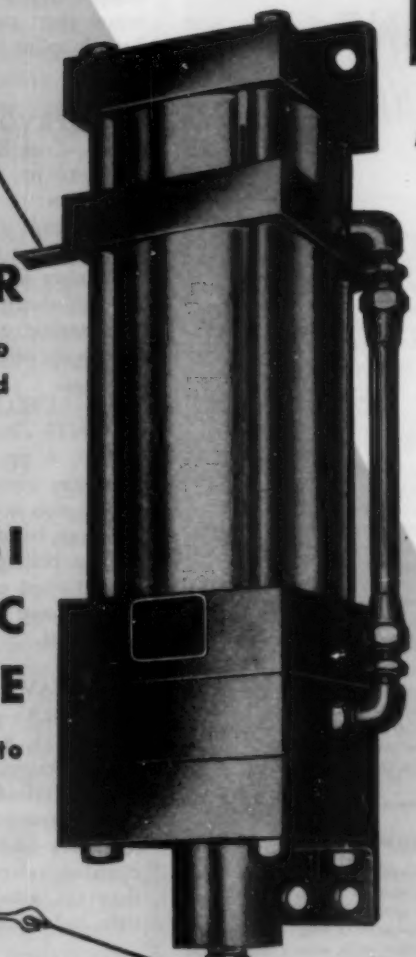
In "Custom-Built" and "Stock" Models

BOOST 80 PSI AIR

Input Range: 40 to 3000 psi Air or Fluid

TO 2000 PSI HYDRAULIC PRESSURE

Output Range: 200 to 10,000 psi Fluid



Get immediate delivery on the popular 5" bore Miller B4 (Air-Miser) Dual Pressure Booster, Model 53, with a 1" dia. hydraulic ram and "stocked" in your choice of either 6" or 12" stroke. Booster ratio is 25 to 1 (80 psi air input provides 2000 psi hydraulic output for driving one or more work cylinders simultaneously).

Separate booster air-oil tanks of 5" bore, in both 6" and 10" heights as desired, are also available for immediate delivery together with foot mounting attachments for speedy conversion of Model 53 to Model 71.

These "Stock" Boosters are identical in quality to Miller "Custom-Built" boosters which are available on normal scheduled delivery in a wide selection of models, ratios and output capacities as described and illustrated in Bulletin B-200. Write for bulletin and prices.

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April 1954
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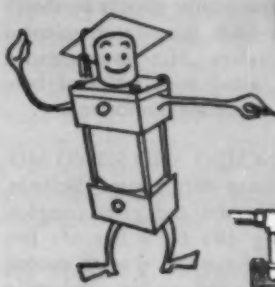

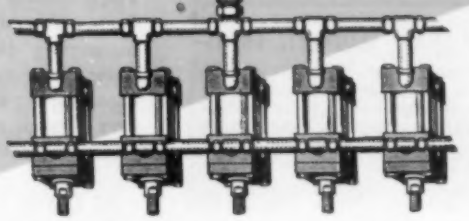

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and similar applications

FULL DETAILS IN MILLER BULLETIN B-200 SENT FREE ON REQUEST
Other Miller products include: Air cylinders, 1½" to 20" Bores, 200 PSI operation; low pressure hydraulic cylinders, 1½" to 6" bores for 500 PSI operation, 8" to 14" bores for 250 PSI; high pressure hydraulic cylinders, 1½" to 12" bores, 2000-3000 PSI operation. All mounting styles available.

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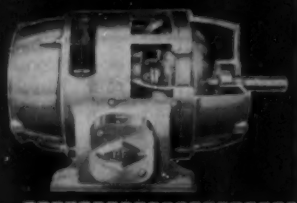
AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS

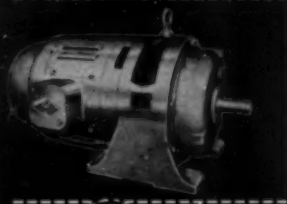
motor design problem?

...maybe one of these REULAND "specials" will solve it!



FLUID-SHAFT MOTOR

Motor with *internal* fluid coupling. Provides smooth load acceleration. More compact than separate motor and coupling. *Assures perfect alignment.* Will start heavier loads than standard motors of same horsepower. Used on cranes, conveyors, mixers, etc.

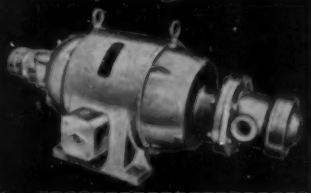


FLUID-SHAFT MOTOREDUCER

Consists of Reuland Fluid-Shaft motor and gear reducer as one compact unit. Converts the motor's conventional high speed into a slow speed, high torque output. Provides smooth starts. Prevents equipment jamming. Used on cranes, hoists, car pullers, etc.

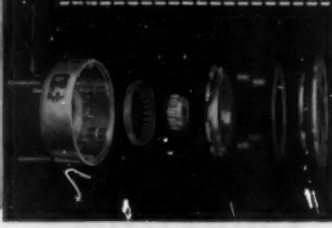
RIGHT-ANGLE MOTOREDUCER

Consists of Reuland motor and worm gear reducer. Provides unlimited mounting versatility. Permits use of 1 high speed and 2 slow speed power-take-off shafts, if desired. Ideal for designing into cramped quarters. Also available with Fluid-Shaft drive motor.



HYDRAULIC PUMP MOTOR

Special end bell flange permits direct, end bell mounting of all standard makes of pumps. Eliminates need for special mounting platforms. Assures absolutely perfect alignment with pump shaft. Available with mounting flange on one or both ends.



THROUGH-SHAFT MAGNETIC BRAKE

"Doughnut" type design allows extension of shaft entirely through brake. Permits use of TWO output shafts per motor. Can be mounted on the input or output shafts (or both) of Fluid-Shaft motors and motoreducers. Only 6 major parts . . . self adjusting . . . half usual length.

OVER 600 SPECIAL ELECTRIC MOTOR DESIGNS

Whatever your drive problems may be, there is a good chance that the Reuland "library of specials" contains a unit that is already tailored to your needs. Its availability will save you development work and put you in production faster.

Write today, outlining your particular problem. No obligation, of course.

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gears covered are: spiral bevel; hypoid bevel; zerol bevel; straight bevel; straight and spiral angular bevel; flywheel ring; straight spur; spur and helical; spline shafts; and gear assemblies.

(31) SERVOMECHANISM DESIGN—Cook Research Labs., Bulletin R-13, 16 pp. Called "Design Considerations of a Saturating Servomechanism," it presents some design considerations of a saturating servomechanism so that the servo designer can deliberately include the saturating characteristics of the control motor and load in the original synthesis.

(32) LEVELING VIBRATION MOUNTS—Barry Corp., Booklet Dr-154-10, 4 pp. Describes and illustrates the advantages of a new line of vibration isolation leveling mounts. They can be used on heavy machines without bolting or shims to give increased plant mobility, reduced maintenance costs and lessening of the noise level.

(33) HEAVY DUTY HYDRAULIC CYLINDERS—Hydro-Line Mfg. Co., Bulletin 53, 8 pp. Contains a complete description on a new series J hydraulic cylinders particularly adapted for electro-hydraulic circuits to absorb the shock loads inherent in solenoid operated valves. Has many detailed drawings, along with tables of bore sizes, and mounting dimensions.

(34) SYNCHRO AND SERVO MOTORS—Ketay Mfg. Corp., Bulletin, 4 pp. Illustrates and gives complete engineering data on a line of: two phase servo motors; synchro control transformers; and synchro receivers in sizes as small as a penny up to a size 31 frame measuring 3.10 in. OD.

(35) CREEP TESTING MACHINES—Baldwin-Lima-Hamilton Corp., Bulletin 4208, 12 pp. Five types of creep testing machines for standard sizes metal specimens. They are: the lever arm and screw type creep machines, microformer type and new SR-4 type automatic relaxation machines and a constant strain rate machine. Illustrations, dimensional diagrams and specifications are included.

(36) DIRECTIONAL & FUNCTIONAL VALVES—The Hydraulic

Press Mfg. Co., Catalogs 801, 821, 841, 178 pp. No. 801 covers 2,000 psi valves with threaded connections; No. 821 covers 3,000 psi valves with flange connections; and No. 841 covers 3,000 psi gasket mounted valves. Illustrations and specifications for the many types of valves in each category. Cross-sectional views showing the port and flow direction are given in every case.

(37) ALUMINUM EXTRUSIONS —Cupples Products Corp., Bulletin, 8 pp. Shows the various products, facilities, in the production of an extensive line of aluminum extrusions, fabricated components, and assemblies. Design, extruding, heat treating, fabricating, assembling and finishing are discussed.

(38) SMALL SPEED REDUCERS— The Falk Corp., Bulletin 2104, 12 pp. Has a large cutaway view showing the internal construction of a small right angle speed reducer with a ratio range of from 5.04:1 to 1459:1. Also shows typical drive arrangements and applications. Sections of the booklet are devoted to: method of selection; hp rating tables; torque capacity tables; sprocket dia; overhung loads; thrust loads; and dimensions.

(39) FHP PACKAGED PUMPS— Allis-Chalmers, Booklet 52B7529B, 6 pp. Gives complete engineering data on a line of packaged fractional hp pumps for air conditioning use with capacities to 80 gpm and heads to 125 ft. A large cutaway view shows the construction and several graphs with performance curves are given.

(40) ELECTRIC MOTORS — The Emerson Electric Mfg. Co., Bulletin X7332, 8 pp. Has illustrations and complete specifications on a line of fractional hp and integral hp motors. Shown fhp motors are: split-phase; capacitor-start; washing machine; blower; oil burner; jet pump; fan duty; and hermetic. Under integral-hp are shown: repulsion-start; capacitor; polyphase; d-c; and hermetic.

(41) LUBRICATING DEVICES — Trico Fuse Mfg. Co., Catalog, 24 pp. Illustrations and diagrams show construction and operation of various types of lubricating units. Included are: glass constant level oilers; gravity

In addition to supplying wire cloth in bulk, a fast-growing division of our company specializes in the fabrication or assembly of parts made from wire cloth. Many companies who formerly fabricated their own mesh parts now avail themselves of this service. After all, we know wire cloth—we've been making it for more than 75 years. We have the facilities, the skilled help, and the experience necessary to turn out these parts accurately and in small lots or in production quantities to meet your production schedules.

Some of our recent jobs are illustrated above. Perhaps one or more of these comes close to something you're working on right now. Write us giving complete details and specifications. If desired our experienced engineers will work with yours in the design of the part so as to make the most effective and economical use of the wire cloth. We shall be happy to quote on your requirements.

NEWARK for ACCURACY

We can furnish wire cloth woven from all commercially used metals. Sizes range from 4 inches (space cloth) to 400 mesh.

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POWDER METALLURGY
can duplicate this part for

61% LESS

MACHINED PART — 18¢
POWDERMET* PART — 7¢

Don't cut parts—*Cut Costs!*
—with YALE Powdered Metal Parts

When it comes to keeping production costs down, American industry turns more and more to powder metallurgy. For here are tough, accurate parts completely ready for assembly...that not only do the job more cheaply, but often *better!*

With identical machined parts, most of the cost goes into the expensive machining operation. The price of *one* machined part will buy up to *six* of the same parts in powdered metal!

Close tolerances, excellent wearability, and controlled porosity are established Powdermet* virtues. Special properties—such as self-lubrication, or unusual electrical characteristics—can also be achieved. Alloys are available exceeding the tensile strength of mild steel.

The answer to your production problems may well be Powdermet* parts...and Yale & Towne. For Yale & Towne has the experience and know-how to serve you best in this rapidly-developing new field.

A qualified Yale & Towne engineer is available to discuss the advantages and limitations of powdered metal parts—*right in your own plant!* He will show you how powder metallurgy may cut costs in *your production operations.* There is no obligation for this engineering counsel.

TYPICAL PM PARTS

Filters	Gears
Bearings	Cams
Switch Parts	Keys
Wheels	Valves
Sprockets	Ratchets
Pawls	And *many more*

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feed oilers; wick feed oilers; thermal and bottle oilers; vari-feed oilers; combination oil cup and oil gage; multiple feed oilers; sump bottles; and under-feed oilers.

(42) INDUSTRIAL PLASTICS — Joseph T. Ryerson & Son, Inc., Bulletin S-1-20-4, 16 pp. Has data on the manufacture, grades, properties, fabrication, and use of laminated plastic sheets, tubes, rods, and special shapes. Performance records of plastic bearings in industrial and marine service are included. Also covers decorative plastic sheets for homes and commercial use.

(43) PLASTIC CAPACITORS — Plastic Capacitors, Inc., Catalog, 40 pp. Gives a complete picture of the status of plastic films used as the solid dielectric in capacitors. Has information on: containers; voltage range; temperature range; resistance; dielectric absorption; power packs; and pulse forming networks. Has illustrations of each model.

(44) BALANCING MACHINE — Tinius Olsen Testing Machine Co., Bulletin 49, 4 pp. Describes and illustrates the features of the Electrodyne, a new principle for automatically measuring the amount and indicating the angular location of unbalance. Also has data on the horizontal and vertical models of dynamic and static balancers as well as the automatic crankshaft balancer.

(45) SMALL 2-CYCLE ENGINES —Power Products Corp., Bulletin, 20 pp. Titled, "The Application of the Small 2-cycle Engine to Power Equipment," it includes 22 illustrations describing application, principles of operation and engineering and mechanical features of 2-cycle engines. Has many cross-section and detailed views.

(46) VARIABLE SPEED DRIVE— Graham Transmissions, Inc., Bulletin, 26 pp. Has large cutaway views and line drawings showing features of operation. Has such advantages as: all speeds from top to zero; close speed holding over wide range; compactness; fast reversal without stopping motor; multiplied torque at low speeds; accurate return to preset speeds. Has operation curves and ratings.

The Shaft Shows the Holding Power of ALLENPOINT Set Screws

ALLENPOINT—Smooth, even bearing surface. Deep point penetration for maximum holding power.

SERRATED POINT—Shaft penetration is slight and irregular. Bearing surface is spotty and rough.

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Has The Set Screw Made A Full Circle Impression?

To obtain the maximum resistance to rotation and sliding movement, a set screw must bear evenly on the shaft. Allenpoint Set Screws reproduce a full circle pattern against their mating surface for increased holding power. Even on shafts of small diameter you get a full circle impression with the smaller cup point of Allenpoint Set Screws.

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The holding power of a set screw will be greatly reduced if the bearing surface is rough and irregular. Serrated point set screws cut into the shaft, raising a chip, removing stock and weakening their grip. Allenpoint Set Screws press firmly into the shaft and form a smooth, deep indentation. The result is holding power that tops any other type point.

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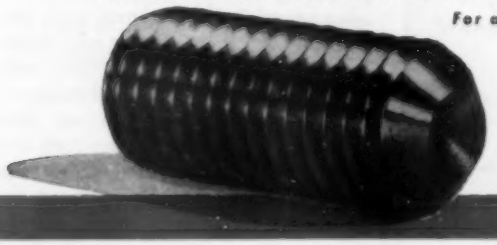

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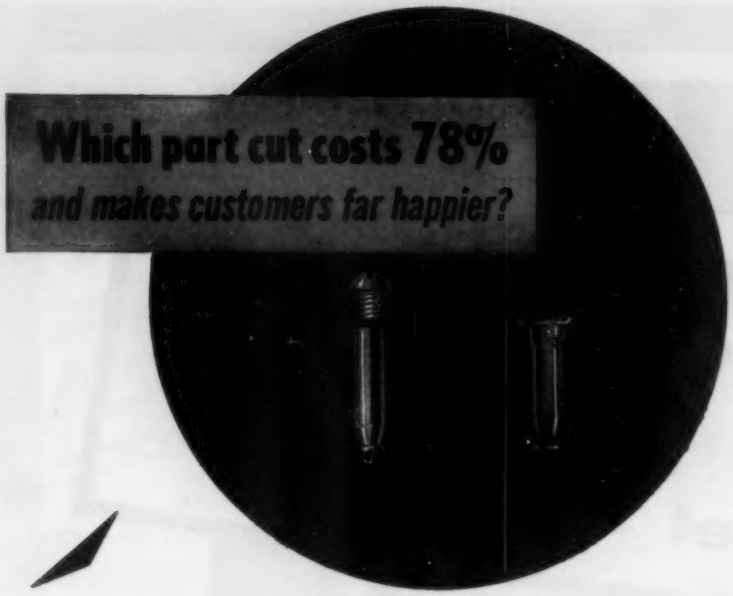

The two-part fastener at left was used to hold the louvres in a line of fluorescent lighting fixtures. The cost of this fastener was high — $35.00 per thousand — and the customer was left with the time-consuming job of mounting the louvres when the fixture was installed.

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Ad Libbing by the Editor

In an article appearing in the New York Herald-Tribune, Dr. Walter C. Alvarez, emeritus consultant in medicine at the famous Mayo Clinic, states, "Investigators have found that persons who had a high intelligence to begin with, grow more intelligent with age, while 'the dumb ones just get dumber.' " That is a statement worth contemplating. In view of my steadily advancing years, I am greatly interested.

If Dr. Alvarez's statement is correct, then it must be concluded that the prevailing practice of enforced retirement at age 65 is a grievious error. Presumably that practice was instituted by the mature men who steer the destinies of business, men who had reached that ripe old age in which decisions are made only after a great deal of contemplation, some study, much decorum and in a ponderous style. This brings up the question, "Was the retirement age of 65 established by men grown highly intelligent with age, or were they dumb men who had just grown dumber?"

My serious judgment is that the decision had been built up by highly intelligent men. After all, many highly intelligent people become physically incapacitated, partially or completely, long before age sixty-five, and why should an "old fogy" be permitted to block the progress of all the men in his department. If the boss has working for him men in five different grades or levels, there will be five men promoted when he quits.

The other side of the picture is that there is too strong a tendency to push out or ignore a man merely because he has passed the half century mark, this in spite of the fact that he may be one of those highly intelligent men who has steadily grown more intelligent. Many men have done their best work after fifty. Ford was about forty-five when he started his factory. He was in his sixties when he instituted the five dollar minimum wage, thereby

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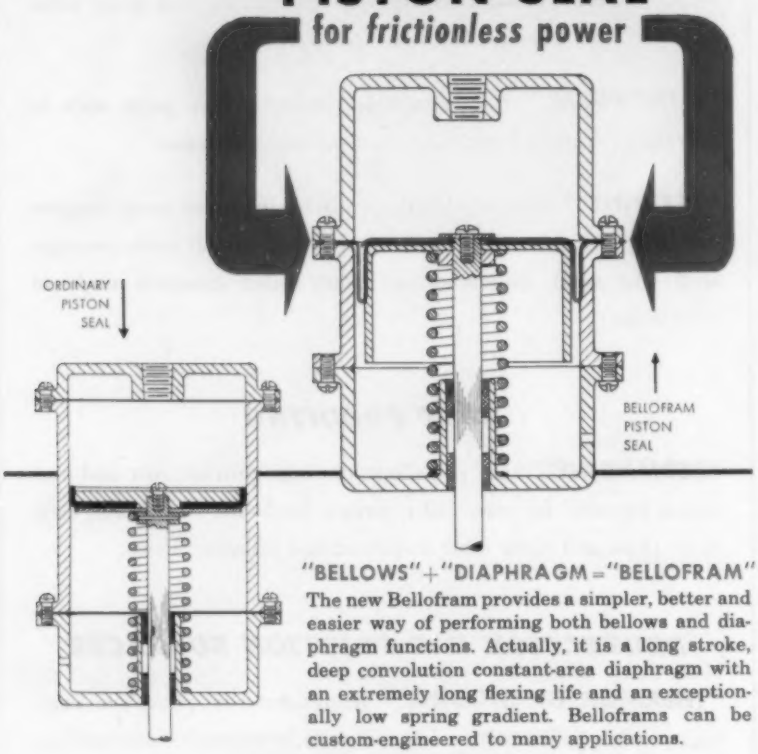

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demonstrating a vision, courage and leadership that was almost entirely lacking in contemporary industrialists.

So do not "sell short" the older men in your engineering department. And when it comes time to retire them maybe they would be extremely valuable as part-time consultants. And the men approaching retirement should "grow old gracefully."

Short Circuits

"Dutchy" was one of those profs that the students always referred to as "a great guy." Small physically, big mentally, he was a bundle of energy that could not stand still. His thinking could out race his tongue but his impetuosity sometimes caused physical action to precede mental analysis. He simply had to get things done quickly; at once, so to speak.

Dutchy was professor of electrical engineering and he had charge of the laboratory courses as well as giving lectures. The laboratory was supplied with d.c. from a motor-generator set in a power house a short distance from the electrical engineering building. And of course there were the usual fuses and circuit breakers.

One day one of the students made a direct short by plugging into the wrong terminal. There was a flash and smoke at the station where the student was. The main fuses blew, the circuit breaker went out and even back in the power house the motor-generator set went out of commission. The twenty or more students in the lab suddenly found themselves with nothing to do.

Without losing any time other than to tell the students to pull the switches at their test stands, Dutchy proceeded to get things "back on the line." He rushed over to the power house, got the motor generator running again, replaced various fuses, closed the circuit breaker and soon all the test stands were again in operation. Then Dutchy went to the test stand where the short circuit had taken place and started asking questions.

"What happened here? How did you come to make such a direct short? You must have thrown a heavy wire right across live terminals! It certainly wasn't an ammeter connected in as a voltmeter! That would simply have burned out the ammeter! What did you do to get such a short?"

The much chargrined student had

EEMCO technical bulletin

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Another new product from the design department at EEMCO is this pilot seat adjustment actuator that can be made to your exact specifications as listed above. With a weight of only 7 pounds, it will handle an operational load of 350 pounds and more. The compact control box, only 2⅜" x 4¾" x 6¼" in size, contains the small and powerful EEMCO motor for driving the two jacks, as well as the clutch, brake, limit travel switches and radio noise filter. The two jacks are coupled for synchronized movement. The actuator illustrated has the following specifications:

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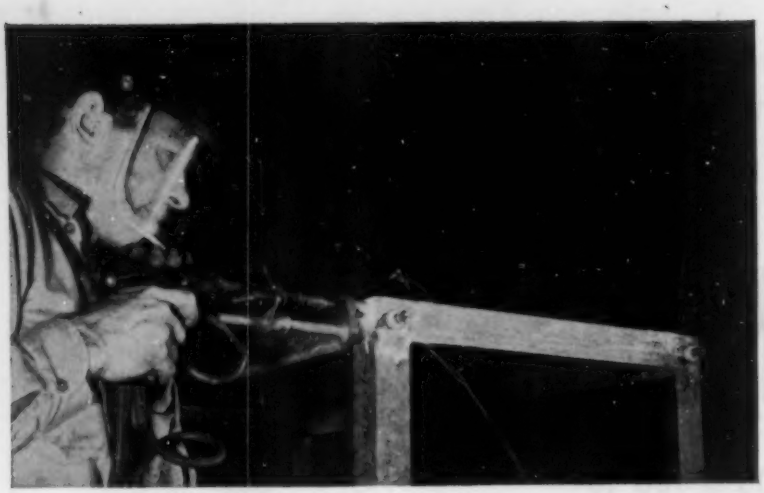


STUD WELDING

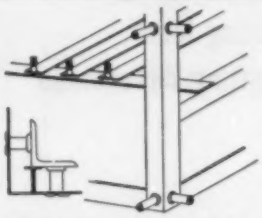
SAVES 2/3 OF CONTROL PANEL FABRICATION TIME

AT AJAX

Stud welding speeds the production of induction furnace control panels for Ajax Engineering Corporation, Trenton, N. J. Tapped pads and standard studs, for holding sheet metal panels and control equipment, are stud-welded to angle-iron frames at speeds up to six per minute.

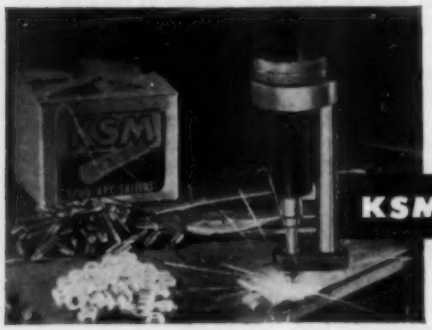
The simple KSM stud-welding process eliminates many time-consuming operations; drilling, tapping, hand welding, grinding, pipe-cutting, and burr-removal are no longer necessary

Savings at Ajax are typical benefits derived from KSM's contributions to production efficiency through arc-welded studs. KSM studs, available in many, *many* standard or special sizes—threaded, bent, or plain—may fill the bill for *your* production needs too. Find out — write KSM Products, Inc., Merchantville 8, New Jersey.

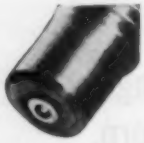


HOW AJAX SAVES TIME

Internal-threaded KSM welding pads, quickly located on the center-punched frame by their precision-centered flux, replace drilling, tapping, screwed-in studs, and saw-cut pipe sections previously welded on frame as spacers to hold sheet metal panels at the proper distance. In addition, as many as ninety KSM standard welding studs on large control units support equipment without requiring the drilling and tapping of holes.



You can always see the flux on KSM studs.



KSM STUD WELDING

WATCH FOR STUD WELDING'S BIGGEST EQUIPMENT IMPROVEMENT, COMING SOON!

in his hand a heavy connector, one end of which was plugged in on some terminal or other.

"I don't know how it happened, professor," said the student. "I got everything connected and plugged in except this plug that I have in my hand. According to my wiring diagram and the way I figure it, this connector ought to plug into that number 6 terminal, so that's what I did."

"What? You mean you took this plug," shouted Dutchy, grabbing it out of the student's hand, "And you plugged it in here?" he yelled, pushing the plug into the number 6 terminal.

Again there was a brillant flash, smoke, fuses blowing and circuit breakers opening. That was the end of that lab session.

One might say that "Dutchy" had proved beyond refutation that the student had told the truth, the whole truth and nothing but the truth. He also demonstrated that it may be better to take a man's word for something that he presumably knows better than any one else, rather than to attempt to prove by demonstration that the man is wrong. The "I just want to prove that he is wrong" attitude can be costly.

One highly amusing meeting at a plant occurred when all the shop foremen were gathered to discuss and "decide" on the "best" type of overhead conveyor to meet all the requirements of the dozen different departments. A "beautiful" design, obviously the pet of the "boss", was described. All the foremen appeared interested and without dissent put their silent stamp of approval on the conveyor. When the general super asked for a show of hands of those who would have the conveyor installed, not a hand went up.

One can only conclude that the foremen, sensing that the super wanted them to express approval, gave it by their silence. But when they were asked to "sign the order" they simply said no by not raising their hand.

Call it prudence or lack of courage, people will rarely take a firm stand pro or con if they have nothing to gain thereby but might well incur displeasure by "opening their mouth." One famous ad advised the reader that, "The wise man works his jaws on chewing gun instead of opening his mouth to get into trouble." Package of gum please. —G.F.N.

ENGINEERING ABSTRACTS

Effect of Stress Recovery on Creep

Abstracted from, "The Creep Deformation of Metals Under Discontinuous Stress and Temperature Conditions," by A. J. Kennedy, Ph.D. *Mechanical World*, February 1954.

CONSIDERABLE WORK has been done on investigating the time-dependent deformation of stress metals. But recent studies of the effect of interrupting or varying stresses on the creep of materials have indicated that the behavior of materials under such conditions can be very different from that deduced from standard creep-testing procedure.

Fig. 1 shows the curve relating creep strain to time for a wide variety of solids subjected to a constant stress. The creep rate is initially high but falls away with time to a roughly steady value. Transient creep makes up the early stage, the second stage being the region of permanent creep. A further, final stage leads to the ultimate failure of the material. Thus, the material hardens or becomes more creep resistant with increasing deformation. When the stress is removed or reduced, a recovery period occurs during which part of the material's former properties are restored. The rate at which the recovery proceeds increases rapidly with increasing temperature. Recrystallization also brings about a relief of internal stresses, new crystals forming at the expense of the old ones. Fig. 1 then represents the deformation of the material under the combined processes of creep and recovery. Since the two processes are stress and temperature dependent, the exact state of the

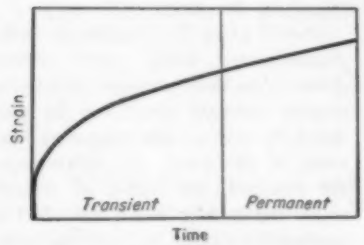


FIG. 1—Typical creep curve composed of transient and permanent stages.

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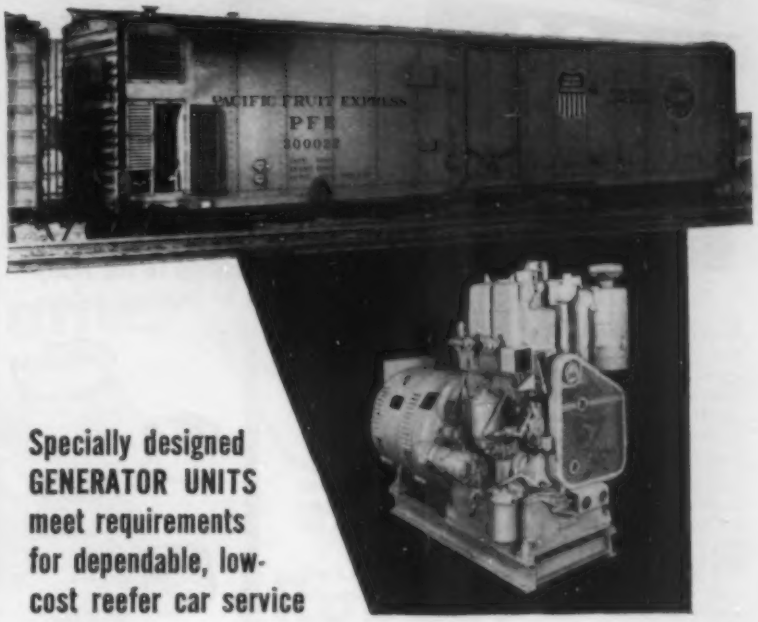

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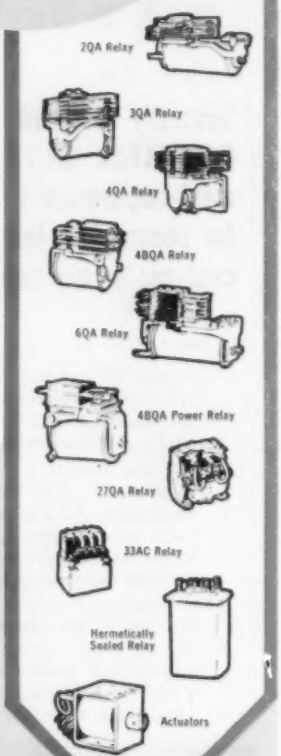

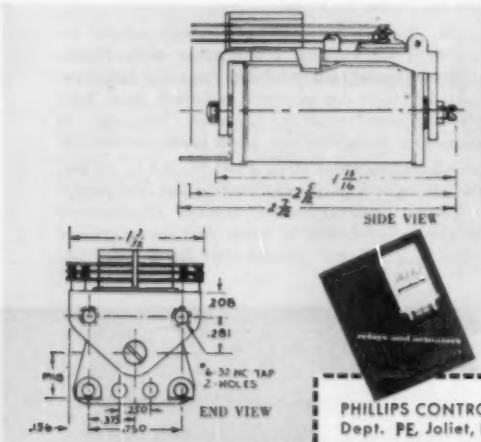

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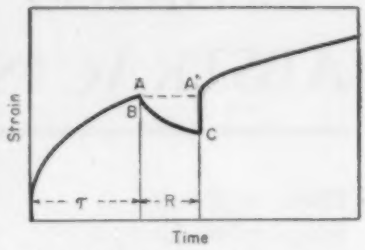

FIG. 2—Typical effect on the creep strain by removing the stress for a period (R).

metal depends on the whole of its previous mechanical history.

If the stress is removed from a metal after some prior creed, such as at *A* in Fig. 2, then a small instantaneous strain recovery, AB, followed by a creep recovery, *BC*, occurs. The important fact is that on reloading the creep curve exhibits a new small transient. After reloading, the creep curve can be considered as the sum of two components: (1) that exhibited by a fraction of the material that behaves as if it had fully recovered its transient creep properties, and (2) that exhibited by the fraction behaving as if there had been no interruption.

When pulse of constant stress are applied to a metal, it is possible to obtain greater creep strains—for a given duration of test—than by applying a continuous stress. Also, the lower the value of the time exponent in the creep function, the greater is the range or fraction of the cycle during which the stress can be applied. The effect of changing the frequency with the cycle duration shows no appreciable difference in the creep strain if the off-load period is not too long. Overall, these observations point out that the frequency is not as important as the waveform, or cycle duration, of the stress pulses. Another result in this problem category is that while the creep resistance of metals varies greatly, their relative creep under continuous and intermittent conditions is essentially the same.

Should creep be considered under discontinuous stress, creep strains greater than those obtained under continuous constant stress can be produced by only a slight temporary lowering of the stress. As interruptions are repeated, the region of second-stage stresses over which this effect is applicable increases and can reach that of zero stress.

When stress increases are accom-

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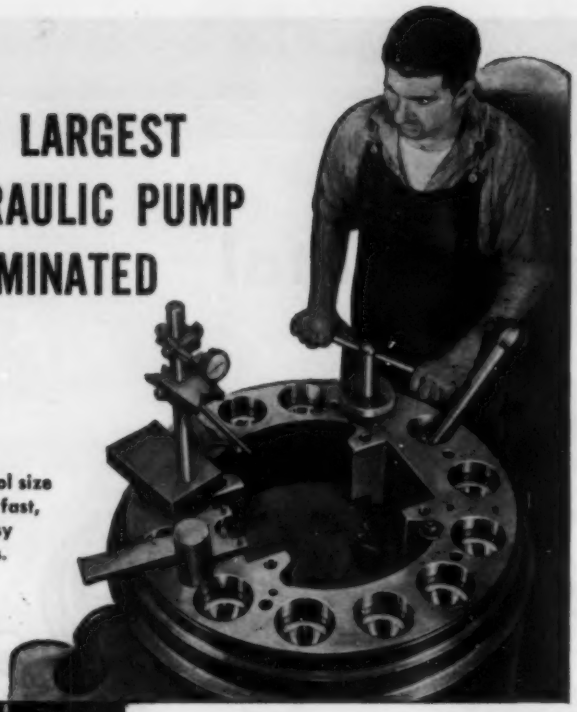

New Waterbury Tool size "300" pumps gain fast, accurate fit and easy service adjustments.

Heart of this huge 20-ton hydraulic pump is the immense revolving assembly of angle plate, connecting rods and pistons. Tilting the angle plate permits rapid reversing under heavy load. Both ends of the connecting rod bearings – at angle plate and pistons – are assembled and adjusted with Laminated Shims. Shown in large picture is angle plate being assembled. Smaller picture gives size of complete revolving assembly. Pumps will be used in Tube Reducing Machine being built by E. W. Bliss Co. for the Tube Reducing Corp.

The largest oil hydraulic high pressure pumps ever built presented a host of new engineering problems—but the old, familiar problems of fast accurate assembly and easy service adjustments were solved by the old familiar remedy . . . *laminated shims!*

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panied by a temperature increase, creep occurs at a higher temperature and recovery at a lower point. If cooling is slow, considerable recovery may occur during the stress-free periods which can seriously affect the creep behavior of the system. Should the stress and temperature cycles be out of phase, the creep involved is less, with the recovery effect far from serious. However, because of the limited investigations published to date dealing with the question of recovery effects, a new look is indicated by those systems heretofore considered immune from problems of creep.

Nameplates In 3-D

Abstracted from "Three-dimensional Nameplates," by A. B. Glanvill, Ch. Engr. of Methods & Design, E. K. Cole, Ltd., Plastics Div. *Plastics*, February 1954. London.

THE SMALLEST TYPE OF NAMEPLATE in general use is the button emblem, frequently used on such items as radios, electric irons, electric heaters, caskets and other comparatively small domestic articles. Emblems can conveniently form a focal point in the general design of the article, such as a centerpiece of a handle or knob or the center of a decorative motif, while they may also be used as a cover for a pilot light and thus become illuminated.

Larger emblems are also employed on major products, the best known of these being motorcar horn buttons. They are also used on refrigerators and washing machines and are frequently of complex and ornate design. They are, of necessity, comparatively expensive, but since they are almost works of art and form a centerpiece on expensive articles, the investment is well worthwhile.

Finishes

The most common method of applying color to nameplates is by the use of paints, a special range of which is now available to suit all types of plastic materials. It is essential to specify the material being used when designing, as paints compounded for use on one material are often quite unsuitable for use on another. These paints are quick drying, available in any color and supplied in spraying, brushing and pastefilling grades. In

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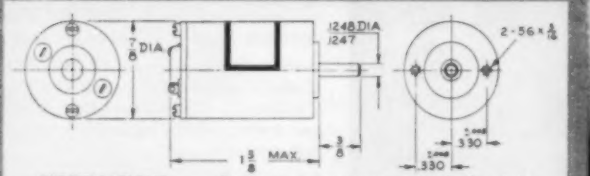

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addition, metallic paints are also used —gold, silver and bronze are common.

Used on nameplates of the "three-dimensional type," are vacuum-plated finishes obtained by depositing a very thin film of brilliant metal on the surface of the molding. This operation is carried out in special plant under high vacuum, and a large number of moldings can be treated simultaneously. By suitable masking, selected areas of the nameplate can be treated and others left plain—thus the lettering can be vacuum-plated while the background is subsequently painted. The most common finish is aluminum, which is readily deposited and gives a brilliant mirror-like silver surface, but other metals, such as pure gold, silver and copper, can also be deposited. Generally, to obtain colors other than aluminum it is usual practice to first spray on a tinted lacquer (assuming the nameplate is in clear material with the letters recessed in the back and the plate viewed from the front) and then to deposit aluminum on the lacquer. The aluminum is then seen through the colored lacquer, and by this means not only can any color be obtained, such as gold or copper, but also any desired shade of color, such as light gold or red gold. The vacuum-plated film, however, because of its extreme thinness, has no wear resistance and must be protected with a coat of lacquer or paint. In general, vacuum-plating is not used on front surface nameplates.

A more recent method of employing vacuum-plated finishes is that of leaving a clear area on the nameplate and fitting behind it a portion of vacuum-plated polystyrene foil. Stamped out to the desired shape and made slightly larger than the actual clear area of the nameplate, it is held in position—close against the back face of the nameplate molding—by any convenient means (such as adhesive tape). The effect is almost the same as vacuum plating directly on the molding, except that a silvering aura occurs because of the gap between the molding face and the foil.

Another method, hot stamping with colored foil, is very popular for stamping names and information on the front of moldings, although it is also used to a small, but increasing, degree for coloring three-dimensional nameplates. It is possible to stamp in several

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colors, although at increased cost, while translucent foils are also available. Large stamped areas should be avoided, and heavy and small type should be balanced out.

When stamping thermoplastics it is also necessary to consider the design of the molding itself, because if there are any changes of section behind the area to be stamped that are likely to cause sinking, failure may occur on the stamping operation, the marking process not being able to accept more than a very small variation in flatness or thickness. When stamping onto the flat back of nameplates or into shallow recesses, it is possible to use continuous ribbon foil.

Silk-screen printing, frequently used on flat surface plastic moldings, is also occasionally used for decorating nameplates. In this method the design is in the form of a stencil cut in the screen, the latter being fitted to a frame. The screen is applied to the surface to be decorated, and the printing ink spread by means of a roller. Therefore, decoration of nameplates by this means must be confined to the flat back or front surfaces, and care should be taken that any recesses are large enough to take a frame. This type of printing is particularly suitable for multi-color work.

The last type of finish to be mentioned is electro-plating, which, although seldom employed, is capable of rather more application than it receives at present. The molding must have the design raised; this is invariably done on a front surface nameplate.

Design of Nameplates

Three-dimensional nameplates are usually molded in clear material with the lettering and design recessed in the back, but they may also be front surface moldings in opaque material with the letters and design raised above the general surface. However, the majority of nameplates are of the former type an dthis style offers the most possibilities in design. The moldings, in clear material, have the design recessed into the back, each part of the design often being cut to a different depth, while the front is usually smooth, although it may be shaped in a curve or flat with rebated edges.

In designing three-dimensional moldings it is necessary to bear in mind the effect of looking through the thickness of the material at the

design at the back. It will be found that the various heights of the letters and design appear as only two-thirds of their actual height, while the colors will tend to be slightly modified.

The form of engraved letters or decorative recesses also requires consideration in design. Deep, thin letters are not particularly satisfactory for spraying and, in general, it can be taken that the letters should be at least as wide as they are deep.

Many forms of molded decoration are employed, some of the most common being various forms and styles of fluting. These flutes are invariably sprayed all over in one color. Other means are diamond facets, concentric grooves and stippling.

Two further points are worth noting with respect to moldings intended to be vacuum plated. First, areas of vacuum plating should be kept small—large portions of plating are apt to be loud in their effect, and although vacuum plating is ideal for lettering or decorations, it is not suitable for extensive backgrounds. Second, the plating will show up any slight defects in the molding in a marked manner—tool marks or blemishes—while slight unevenness in stippling or sandblasting will throw up shadowed areas.

A reversal of the recessed type of lettering can also be mentioned, wherein the letters are raised on the back face instead of being recessed into the molding. The three-dimensional effect is retained, but tool costs tend to be reduced. Painting is also made easier, since it is necessary to paint only the tops of the letters (although these will appear fully painted when viewed from the front). Raising a rim around the molding will provide a flat back for fitting purposes.

Fastenings

Always a problem with molded nameplates is the securing of the plate to the component on which it is to be mounted. By far the easiest and cheapest method is to provide one or more fixing holes and to fasten the plate by means of screws, eyelets or rivets. With a fastening of clean design, plated and polished, the effect can add to the general appearance. Fastenings such as bolts or screws with specially designed heads can be used, but even standard plated items will be found attractive. If this type of mount-

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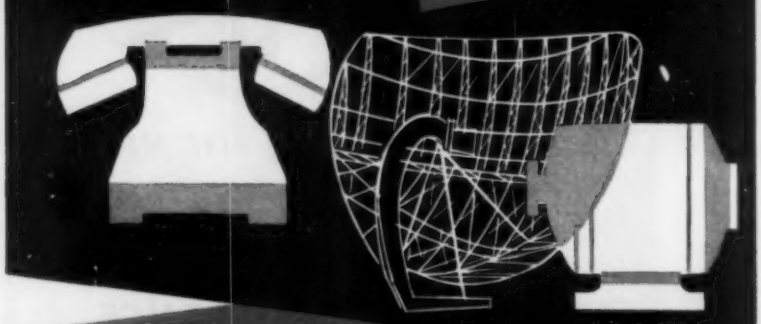

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ing is to be used, however, thought should be given to the holes in the molding, since knit lines are likely to form if they are molded. These are likely to show up if the background is painted a light color, in which case it may be desirable to drill the holes.

The second common method of attachment is to raise molded lugs from the back of the nameplate which will pass through suitable holes in the component. These lugs are then hot pointed over or secured by spring clips or any other suitable means.

Adhesives are occasionally used to secure nameplates, but this method is not particularly to be recommended.

Ball Piston Pumps and Motors

Abstracted from paper presented at the Ninth National Conference on Industrial Hydraulics, Oct, 1953, Chicago, Ill., entitled "Ball Piston Pumps and Motors," by W. T. Rauch and H. Stern, Development Engineers, General Electric Co., Schenectady, N. Y.

THE BALL PISTON PUMP combines in a compact simple package many desirable features that are indicative of good hydraulic equipment design. A steel ball is used as a piston. The schematic sketch, Fig. 1, shows such a ball in a bore, to which oil is admitted, at low supercharge pressure through check valve *A* and can be discharged through check *B*. The ball can be made to reciprocate in the bore by a simple cam, rotating about *O*. This completely replaces the piston, crank shaft, wrist pin, connecting rod and associated bearings commonly found in positive displacement pumps.

Expanding the basic principle of a ball piston pump, a multiple cylinder unit can be constructed, Fig. 2). The radial cylinder bore arrangement pro-

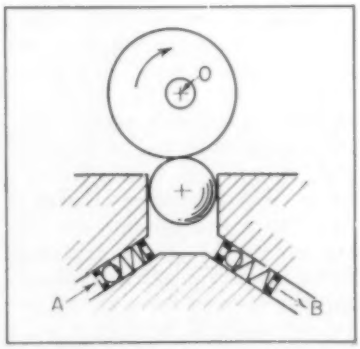

Fig. 1—Schematic of ball used as piston.

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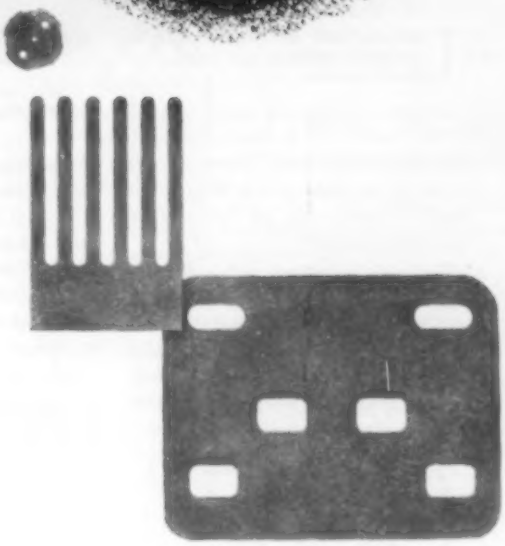

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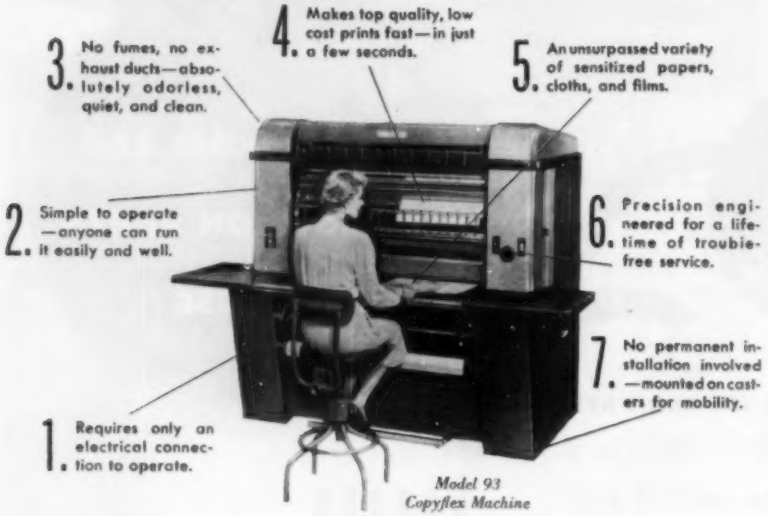
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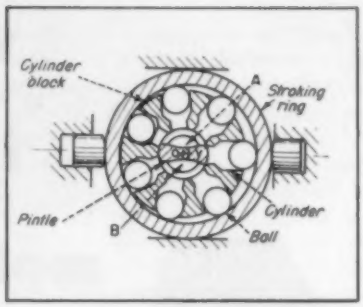

Fig. 2—Multiple cylinder ball piston pump.

vides several desirable features: (1) no mechanical piston return is required. (2) Centrifugal force on the ball pistons is sufficient to maintain contact between the balls and the race. (3) The ball bearing type stroking ring is easier to machine than a profiled oam. (4) All reaction forces can be supported without the use of a thrust bearing. (5) The controlling forces and the inertia of the moving parts are small.

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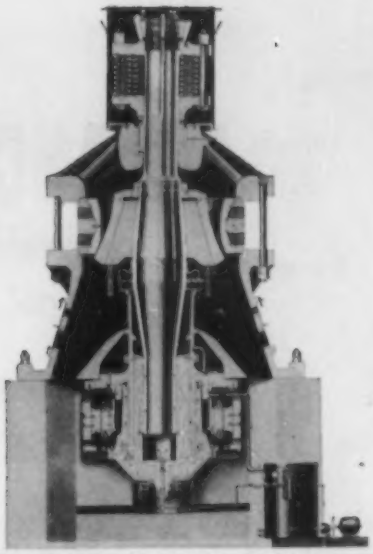

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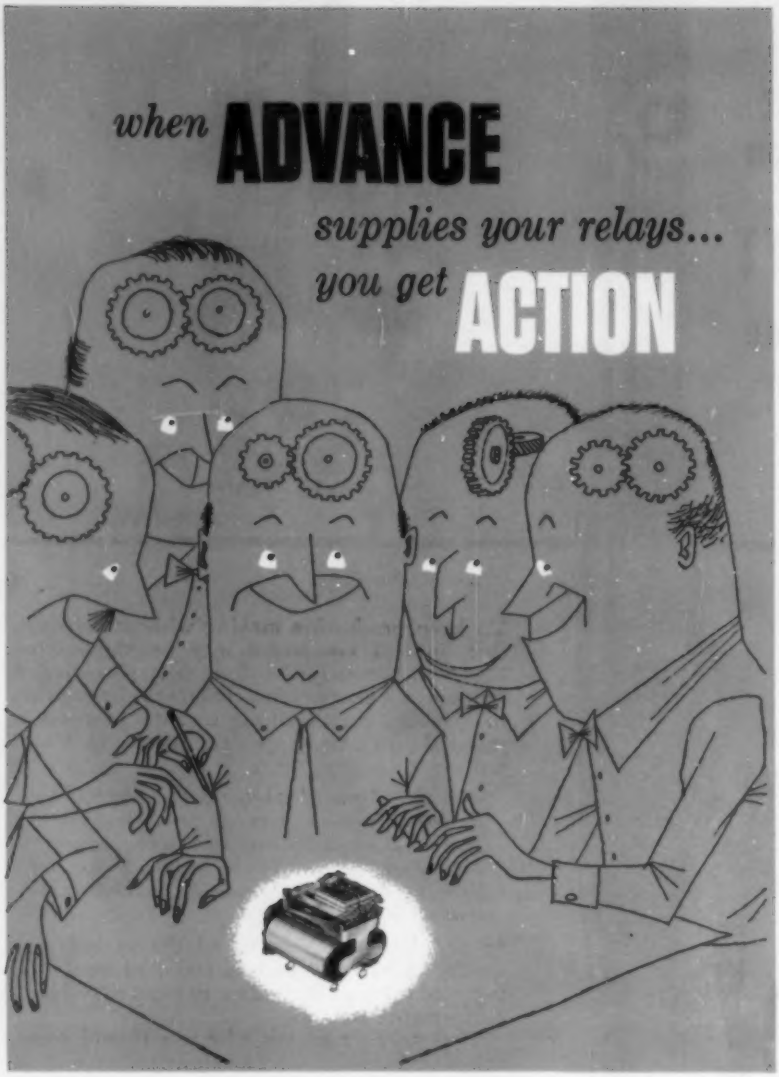

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change a pump from full stroke in one direction to full stroke in the other direction is small and, therefore, can be accomplished very rapidly by a simple stroke actuator. Small hydraulic pistons of approximately the same diameter as the balls of the unit are sufficient to supply the necessary stroking force. The low inertia of the stroking mechanism allows the unit to vary pressure or flow very rapidly.

Radial ball piston units can also be built on a two cycle principle using an elliptical cam in place of the eccentric circular stroking ring. In this case, the pintle pin must provide four passage ways for oil, two for inlet oil and two for outlet oil. This configuration allows each ball to perform two pump cycles per revolution of the cylinder block. Such a pump will deliver twice as much power per revolution as a single cycle unit.

Ball Piston Motors

Any ball unit will motor as well as pump. It is evident from Fig. 2 that pressure supplied to a ball from passage *A* will cause the ball to move outward in the cylinder bore and thereby supply a clockwise motoring torque to the cylinder block. Ball piston units which are entirely devoted to motoring duty are usually built with the stroking ring fixed at maximum displacement.

In a ball unit the cylinder block with the ball pistons and the drive shaft form the only rotating members. It is very important that the inertia of these parts can be held low in ball motors. Because of the higher torque to inertia ratio, two cycle ball piston units are most frequently used as fluid motors. For instance, a typical ball motor when supplied with 3,000 psi fluid will accelerate from stand still to a speed of 14,000 rpm in five milliseconds, (Fig. 3). This speed of 14,000 rpm is attained in approximately the first ½ revo-

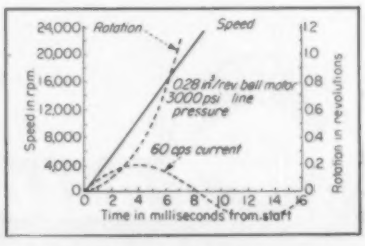

Fig. 3—Starting data of ball-piston motor.

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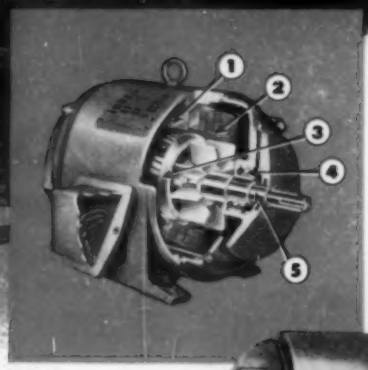

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lution of the shaft. This same motor will idle smoothly at low speed with as little as 3 psi pressure drop. The initial breakaway pressure is only a few psi higher.

A Constant Pressure Pump

A constant pressure pump requires different characteristics than the strokable pump described previously. In addition to controllability, efficiency and endurance at sustained high pressures for long periods of time can now be expected.

A constant-pressure ball pump must be operated at relatively high shaft speed in order to displace a large amount of fluid in a given length of time, thereby reducing the quantity of leakage percentage-wise. The ball pump not only can achieve operation at high speeds, but it is at these speeds that its performance is particularly noteworthy.

A ball unit may be operated at ball surface speeds of 100 ft/sec. In terms of shaft speed, small units delivering from 2 to 8 gpm are operated at 10,000 to 20,000 rpm. These units may be direct coupled to high speed electric motors or turbines without the use of reduction gears. A constant pressure pump can easily be built with a power to dry weight ratio of 2 hp/lb. Larger pumps delivering 10 gpm and up must be operated at proportionally slower speeds. The largest constant pressure pump now being contemplated will have an operating speed of 7,000 rpm delivering 35 gpm at 3,000 psi.

A small motor weighing about 3 lb can develop peaks of 30 hp at 15,000 rpm. The slip in such a motor is inherently lower than that of a similar ball piston pump and its efficiency is therefore good even at high speeds.

One of the most promising applications of ball piston units is in the field of hydraulic transmissions. Here the shape of the radial piston pump or motor produces a compact package and the complete radial symmetry allows us to use the principle of the differential transmission to best advantage. In these transmissions we take widely varying input speeds and deliver a constant output speed to drive an aircraft alternator. This can be accomplished in a stepless manner, since the transmission ratio is a function of the ratio of hydraulic displacements of the ball piston units involved.

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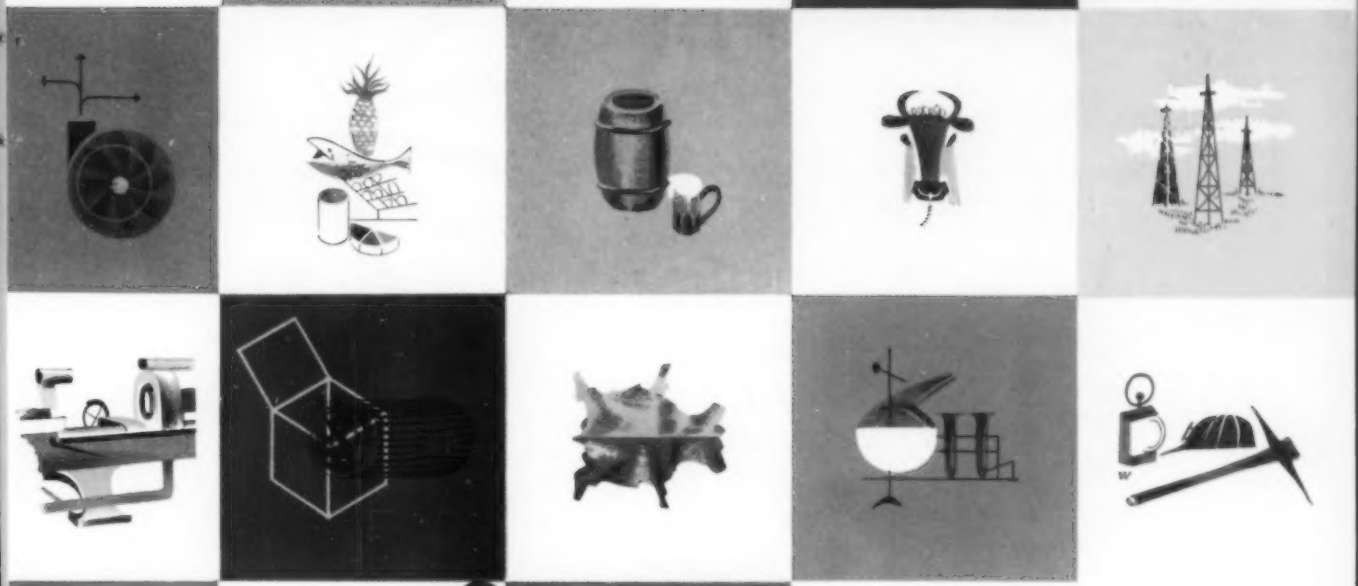

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OUR READERS SAY

Letters should be addressed to The Editor, *Product Engineering*, 330 West 42nd St., New York, 36, N. Y.

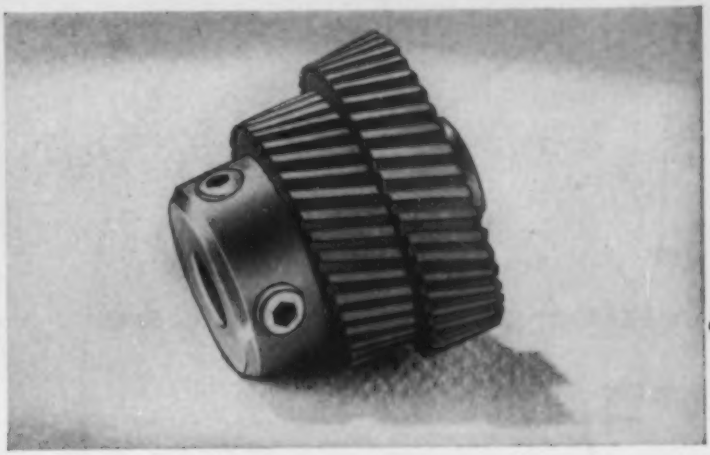
And Still More on "Expensive Fancies"

To the Editor:

My attention has been directed to your editorial "Expensive Fancies" which appeared in the December 1953 issue of *Product Engineering*. Inadvertently, I didn't notice it at the time of publication.

I have been a steady reader of *Product Engineering* for over twenty years. . . . You will recall, I often expressed the opinion that your magazine was on a level with the best. Also, I have contributed many articles which were published in *Product Engineering*. My article "Basic Standard Drafting Practice Guarantees Correct Interpretation," which appeared in July 1947 issue of *Product Engineering*, promoted drafting practices which are contrary to simplified drafting. I am sure that you will agree that no individual is more interested in drafting economy than a Chief Draftsman. He is anxious to please his Chief Engineer by getting drawings released to the shop as promptly as possible and at lowest cost. But he must provide drawings that are not subjected to possible misinterpretation. To achieve this objective, a Chief Draftsman must insist on accuracy, legibility and completeness to prevent later confusion, hold-ups and errors. To follow any other course invariably results in difficulties with manufacturing personnel. The extra time and effort utilized in preparing accurate, legible, and complete drawings is unquestionably justifiable from an economical standpoint. To be specific, sensible drafting practice is good engineering, and there is no substitute for good engineering.

Costly errors, waste, drawing misinterpretation, confusion, panic, and frustration usually result when the philosophy is to place greater emphasis on speed with the penalty of allowing sound engineering drafting practices to



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lag behind. There is no sense, nor is it good business practice, in saving two hours on Monday in preparing an incomplete drawing and then later repeatedly, spending hundreds of hours straightening out something that could have been easily avoided by taking an extra hour or so to properly complete, in the first place, on Monday.

In this age of nuclear energy, in this fantastic era of speed, invention and technological progress, the need for comprehensive drafting practices are greater than ever. Extremely close tolerances, surface finish and strength requirements, etc., must be rigidly held on the extremely complex parts used on modern jet aircraft engines, machine tools, etc. It is becoming more and more evident that the most economical and logical place to correct mistakes in designs is on the drawing board during the early stages of development. Mistakes, poor designs, and oversights can be held to a minimum or completely averted if the sound principles of good, practical engineering drafting practices are judiciously followed. After establishing the principle engineering requirements, the first step in the engineering routine of developing a design, from first conception or idea, is to prepare layout drawings. Accurate layout drawings, not sketches, should be prepared to show general characteristics, primary movements, secondary movements, motions, clearances of moving parts, etc.; checking layouts should be prepared to determine the manner in which parts of the design are assembled; accumulation of tolerances layout should be prepared to study the possible results of extreme limit stacks, etc.

A reasonable amount of "bugs" are expected and usually present in any design. A design can be "bugged-out" much more easily if drafting and design mistakes are held to a minimum. The only "bugs" that can possibly be justified are those that can only be detected from tests or actual performance.

After the layout drawings are completed and approved, accurate, complete, legible, detail drawings, not sketches, should be carefully prepared. Completeness and scale are essential in order to attain the proper proportions, application of the part, both in relation to itself and to associated parts, correct clearances, proper performance, correct assembly, reliability,

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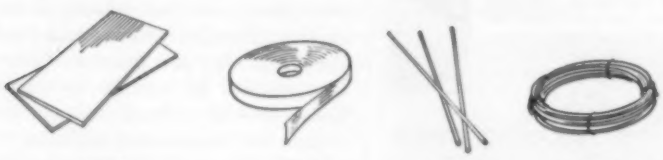

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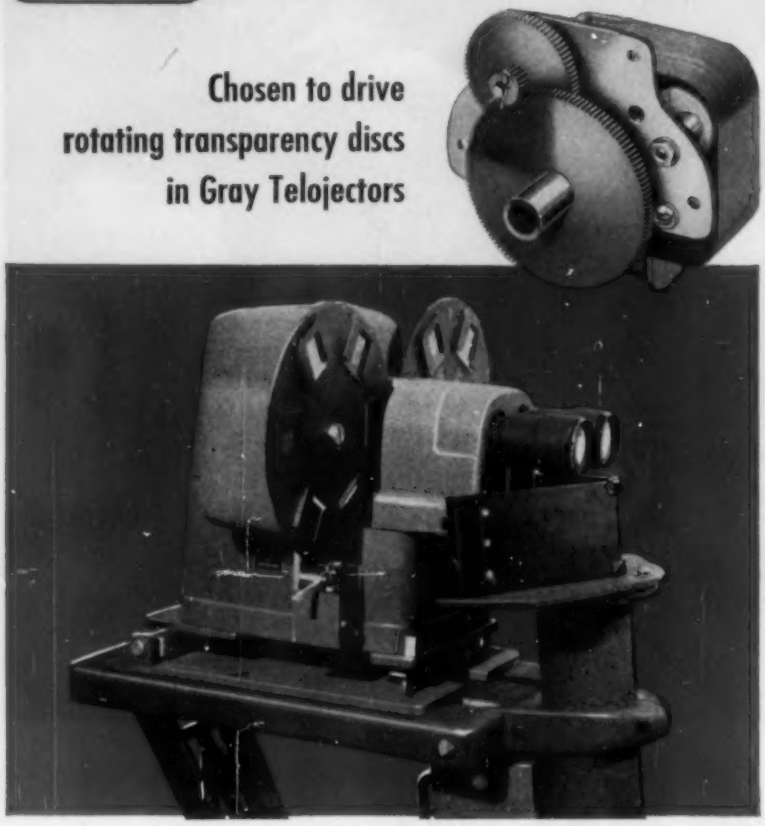

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safety, required strength and other design objectives.

With sketches, as proposed by simplified drafting practices, it would be impossible to discover and avoid interferences, undersize wall thicknesses, improper breakouts, poor proportions, faulty design, improper assembly conditions, oversize elements, misalignment, and other mistakes and oversights.

It is also questionable whether any man hours would be actually saved by sketching. It is much easier and faster to draw circles with a compass, and straight lines with a straight-edge than to draw them free hand.

Your attack on the efficiency of American industry production methods is not constructive. Over a decade ago, Joseph Stalin, at the Moscow Conference, said the outcome of war depended on machines and that the nation producing the most machines would be victorious. A few years later at Teheran, he said the war would have been lost without American production. Russian leaders should be constantly reminded of these statements. Editors, by stressing this point, might help avoid World War III. It is unwise and dangerous to underestimate America's industrial might.

Accepted and widely used American drafting standards permit the use of many sensible short cuts. For instance, graphic representations are used for screw threads, spring, gears, splines, etc. A few gear teeth must often be shown to specify specific hardness or edge breakage requirements. Electrical and surface finish symbols and partial drawings are used to great advantage. The practice of detailing new parts that are similar to existing parts are handled by the use of modified duplicate tracings. American Chief Draftsmen are constantly searching for practical short cuts so that the abilities of designers may be applied to more important design considerations. It is unusual to find an American Chief Draftsman who isn't cost conscious.

I am sure you would think differently about simplified drafting if you sat in a Chief Draftsman's chair for a few weeks. It is simple for an Editor, like yourself, to criticize everybody. Today you tell Chief Draftsmen that greater drafting economy can be easily achieved by merely omitting arrowheads, dimension lines, scaled views, etc from drawings. All is needed, you

claim, is a rough sketch. Next, you will tell production men that all is needed is a crude hammer and chisel, and that machine tools are no longer required.

As long as simplified practice is the topic of discussion, perhaps you would consider the possibility of firing all of your editors. Why not publish articles exactly as received from your contributors and print them on type-written ditto masters? Why not make free hand illustrations and print them on fig leaves? Most articles, particularly editorials, are too lengthy and could probably be condensed, simplified, at least 99 percent.

I should also like to stress that a designer must be a good draftsman. A design engineer is constantly confronted with problems of both theoretical and practical nature. He must have an excellent background in practical drafting and manufacturing practices. Design work also requires personnel with resourcefulness, originality and who are acquainted with the latest development and their applications in the fields of mechanics, physics, electricity, and allied arts and sciences.

I doubt that you will like the nature of this letter any more than I like the substance of your editorial "Expensive Fancies."

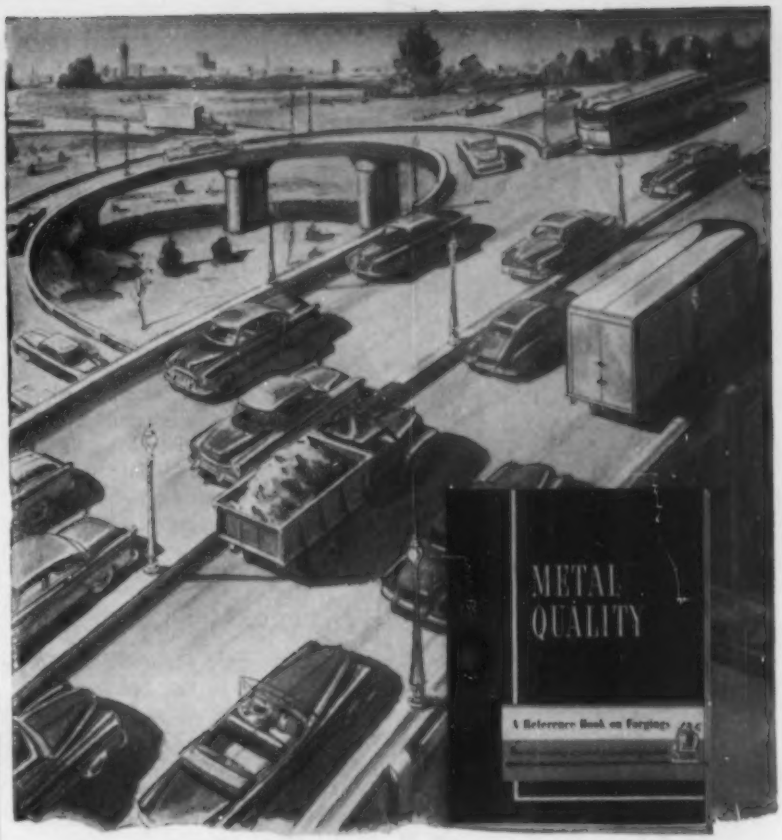
Although we strongly disagree about drafting practices, I hope you will agree with Voltaire, like I do, when he said, "I disapprove of what you say, but I will defend to the death your right to say it."

—GEORGE E. ROWBOTHAM
Chandler-Evans
Div. Niles-Bement-Pond Co.

To the Editor:

Your editorial in the December issue of *Product Engineering* gives persuasive arguments for simplified drafting. It is true, drawings can be simplified and still contain the same amount of information. This still does not solve the problem of instituting the new method throughout the country. Designers and engineers have enough difficulty in conveying information to the shop with the present conventional drafting methods.

The fact that this problem does exist (and it would be naive to deny it) gives some idea of the enormity of the task of introducing a new system. It would mean overcoming all the teach-



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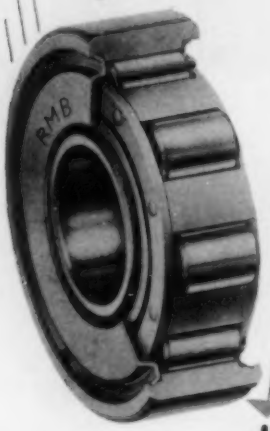

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ing and conventions of a system that has been used in the shop since the formal introduction of drafting.

The simplified system would probably be feasible within one corporation, provided that all the work would be done in its own shop; and also provided that all drafting and shop help were properly schooled in the system.

On a countrywide basis, it would take decades to inaugurate a new system because of the tremendous educational and standards problems involved. Therefore, I feel it will take at least twenty years before a simplified drafting system can be effected throughout the industry.

—Sol Zwirn
Reeves Instrument Corp.

To the Editor:

Your editorial "Expensive Fancies" was excellent, in our opinion. Can you advise us whom we should contact for a copy of G.E.'s *Simplified Drafting Procedure?* We would like to get a copy and follow it. We certainly agree with you and intend to practice what you preach.

Your kind cooperation in answering this request will be most gratefully appreciated. —A. R. Viel
Project Engineer

Ed—The book "Simplified Drafting" by Healy & Rau is in substance a reproduction of G.E.'s Handbook of Simplified Drafting. You can obtain the book from John Wiley and Sons, 440 4th Avenue, New York, N. Y.

To the Editor:

The editorial "Expensive Fancies" appearing in the December number and some of the answers appearing in the February number deserve further comment.

How many times does a sketch go into the shop and have the foreman question a dimension? The question is created by dimensions that are not to scale. A drawing to scale checks the dimension to a dimension that is not to scale and is marked accordingly. A plain square drawing saves much time in the shop.

Coloring parts in the assembly drawing is not a new idea. It was used years ago. In fact, at one time I believe the use of water paints was in practice to some extent. The drawing

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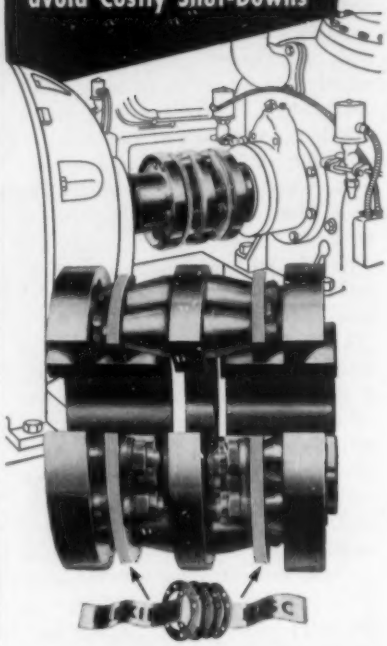

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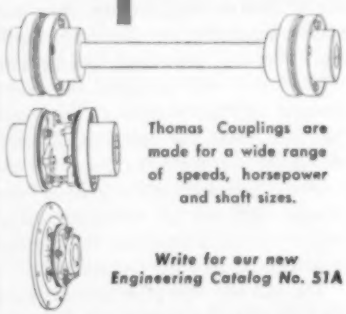
NO LUBRICATION	No Wearing Parts. Freedom from Shut-downs.
NO BACKLASH	No Loose Parts. All Parts Solidly Bolted.
CAN NOT "CREATE" THRUST	Free End Float under Load and Misalignment. No Rubbing Action to cause Axial Movement.
PERMANENT TORSIONAL CHARACTERISTICS	Drives Like a Solid Coupling. Elastic Constant Does Not Change. Original Balance is Maintained.



Thomas Couplings are made for a wide range of speeds, horsepower and shaft sizes.

Write for our new Engineering Catalog No. 51A

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA, U.S.A.

Stainless Steel here...

and
Stainless Steel here...

HELP RESIST HEAT HERE

To withstand the scorching blasts that thunder through them, jet engine tailpipes and exhaust cones are made of Republic ENDURO Stainless and Heat-Resisting Steel.

There's an idea here for manufacturers whose products or process equipment may be prematurely aging due to high temperature conditions.

As the jets have proved, ENDURO resists heat. In great quantities. For a long time. And, it offers much more. It stubbornly resists rust and corrosion. It resists abrasion and denting. It maintains its great strength at wide temperature extremes. It provides that strength without prohibitive weight and bulk. It stays easy to clean. It is easy to fabricate.

For your future designs, ENDURO is available in many forms—sheets, strip, cold-finished bars, forging bars, wire and tubing. Through Republic's exclusive "Three-Dimension Metallurgical Service," you get help in applying ENDURO Stainless and Heat-Resisting Steel most efficiently and economically.

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REPUBLIC STEEL

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ENDURO STAINLESS STEEL

Other Republic Products include Carbon and Alloy Steels—Pipe, Sheets, Strip, Plates, Bars, Wire, Pig Iron, Bolts and Nuts, Tubing

Power that pays off!

that's Le Roi heavy-duty power

Built by a manufacturer who concentrates exclusively on the problems of the heavy-duty field

POWER you can punish. Power you don't have to pamper. Power that pays off in dependable service — in operating economy — in quick field maintenance. That's Le Roi power!

A typical Le Roi-engine application in the farm-equipment field — powering a Papec Forage Harvester. Le Roi power is first choice of many manufacturers of oilfield, construction, industrial and agricultural equipment.

A Le Roi is no automotive lightweight — it's a power-packed, valve-in-head engine designed especially for heavy-duty service. You get the advantages of weight and stamina that stand the abuse handed out to field equipment, without costly breakdowns. And you get many features that add to the dependability and economy of operation — features that have been proved wherever tough conditions test soundness of design and quality of materials and workmanship.

Yes, sir, Le Roi is your best power buy—whether you're getting new equipment or replacement engines, or whether you're looking for an efficient power plant for the equipment you've designed. Le Roi has a full range of sizes from 15 to 635 hp — for gasoline, natural gas, butane.

LE ROI

LE ROI COMPANY

A Subsidiary of Westinghouse Air Brake Co. E-91

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was made on manila drawing paper and sometimes it was inked in with all the different colors. Now we use cross sectioning which is obviously much better and faster to produce.

As to the showing of gear teeth, knurling, rivet heads and fillets, years ago this was done to extreme and some companies still do this. However, the majority do not. The practice of drawing gear teeth stopped 30-odd years ago.

Only a good drawing instrument is able to draw a radii circle. Therefore the larger percentage of draftsmen draw free hand radii to show fillets.

For the past 30 years I have not had the good fortune to work for a company that would pay me to make a beautiful drawing instead of a practical one. These same companies a few years back would give us instructions to save time where feasible. "Do not cross section a job unless absolutely necessary." Things have changed considerably in the last 10 years.

Today the draftsman has too many company standards to work to. He spends a lot of time looking up the company number for accepted standards. When his drawing is made and goes to an outside vender a standard book must accompany it from start to finish. It is far cheaper to make a change on paper than it is to throw a part away and start all over again.

—N. T. REED
Chief Engineer

Ed—We heartily agree with everything Mr. Reed has stated.

Historical Note

To the Editor:

I have read for some time with interest your column "Sans, Souci" in *Product Engineering*. May I add some information to your column in the January issue, regarding Frederick the Great.

Frederick the Great was never emperor or Kaiser of the Roman German Empire. The Roman German emperor in the 18th Century was, as far as I can remember from school, Charles VI of Austria, and after his death in 1740, Francis I, Duke of Lorraine, the husband of Maria Theresa of Austria, was elected German Emperor. Maria Theresa ruled in Austria until 1780. Her husband died earlier, and after

This walking beam for a heavy duty machinery trailer originally was produced as a weldment.

A review of the design by the manufacturer's engineering department and the steel foundry engineer showed that the part could be produced more advantageously as a steel casting. Conversion resulted in a reduction in cost of 30% and a reduction in weight of 23%. Appearance also was improved.

Proof of customer satisfaction is the fact that the number of these parts produced as steel castings already totals several thousand.

* * *

Here is another example of the foundry cooperation which is resulting in lower costs and improved products through redesign to steel castings.

This service is offered without cost or obligation. It makes available through your foundry representative the full results of the development and research program carried on by the Steel Founders' Society of America.

Product Development Contest . . .

Two awards of $1000 each and four other cash awards—a total of $3500. Entries to be new ideas or applications of steel castings, and case histories of new jobs put into production. Write for folder giving full information.

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STEEL FOUNDERS' SOCIETY OF AMERICA

920 Midland Building **Cleveland 15, Ohio**

Design and Build With Steel Castings

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—says REPUBLIC AVIATION CORP.
Makers of the famous F-84E THUNDERJET

"Under actual tests, LUBRIPLATE extended bearing life fifty per cent or better as compared to other lubricants. It was also found that, during test, LUBRIPLATE increased efficiency of machines twenty per cent by reducing friction loss. Republic has been using LUBRIPLATE successfully for the past eight years."

REGARDLESS OF THE SIZE AND TYPE OF YOUR MACHINERY, LUBRIPLATE GREASE AND FLUID TYPE LUBRICANTS WILL IMPROVE ITS OPERATION AND REDUCE MAINTENANCE COSTS.

LUBRIPLATE is available in grease and fluid densities for every purpose... LUBRIPLATE H. D. S. MOTOR OIL meets today's exacting requirements for gasoline and diesel engines.

For nearest LUBRIPLATE distributor see Classified Telephone Directory. Send for free "LUBRIPLATE DATA BOOK"... a valuable treatise on lubrication. Write LUBRIPLATE DIVISION, Fiske Brothers Refining Co., Newark 5, N. J. or Toledo 5, Ohio.

his death her son, Joseph II, was elected Roman German Emperor. This was in 1765 and he died in 1790. The palace of Sans, Souci was built by King Frederick II of Prussia, who was also called the Frederick the Great.

—J. H. TREVITT
Dictaphone Corp.

Ed—Mr. Trevitt is, of course, correct. Frederick the Great was a Prussian.

The February Editorial

To the Editor:

I have just read with great interest your editorial appearing on page 127 of the February issue of *Product Engineering*.

This editorial, which is entitled "Will the NSPE Take Over?" poses a very important question. It will surely accelerate some active thinking.

—ROSCOE H. SMITH
Reliance Electric & Engineering Co.

Ed—We hope it will.

To the Editor:

I have read and generally agree with the editorial in your February number. You will probably be interested to know that of 340 freshmen who started engineering last September, more than 90 have already been dropped for poor scholarship. I believe this is typical of most good engineering colleges.

The basic cause as I see it is the present philosophy of mass education in which a public school teacher may not fail a poor student and thereby the poor students are carried along to upper classes where they inevitably lower the teaching standards. In the larger high schools there is a possibility of special pre-college classes but still the same philosophy applies. In smaller schools a special pre-college training cannot even be attempted for economic reasons.

Obviously, an aroused citizenry that will pressurize the State Legislatures is one answer to this problem. —*C.H.A.*
Director of Mechanical Engineering

Clarification

To the Editor:

Considering the number of selenium rectifiers in use today, I am always shocked at the ignorance of the technical man as to the fact that they even

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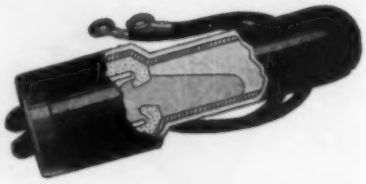

Durakool pressurized all-steel **mercury tilt switches** have more than made good on what may have seemed like extravagant claims a few years ago. The list of Durakool successes grows each year. Seven sizes, 1 to 65 amperes. 3 to 4 weeks delivery. Your production schedule is met.

WITHSTANDS HIGH TEMPERATURES

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DURAKOOL, INC., Elkhart, Indiana

Durakool
ALL-STEEL MERCURY SWITCHES

CORNING GLASS BULLETIN

FOR PRODUCT DESIGNERS

3-WAY glass grounds electricity, conducts it, and fights off heat rays . . . Glass gun shoots oil . . . An introduction to solving some materials problems.

3-way glass

E-C glass is a PYREX brand glass panel (or tube) permanently bonded on one side with a thin (20-millionths inch) transparent coating that conducts electricity. (The E-C stands for Electrically Conducting.) Run a current through it and you get an efficient heating element. Ground it and it drains off charges of static electricity, as any metal would. (But you can *see through* the E-C glass). Let it stand by itself, with or without electrical or ground connections, and E-C glass reflects infrared heat rays.

E-C radiant glass panels drying lacquer on plastic sheets.

Since 1950 we've worked with a number of customers on applying E-C glass, quite successfully, as a heating element in space heaters, home appliances and industrial drying equipment. (It's especially useful where an uniformly distributed heat flow is wanted.)

One of the most recent applications is shielding certain elements of IBM's new electronic calculator from static that might disrupt the workings of this remarkable abacus.

And a well-known steel producer has erected a curtain of E-C glass between shear pulpit operators and the intense heat of the fiery steel bars moving through the shear. (About 60% of those sizzling infrared rays bounce off the E-C curtain.)

Not every day, but every now and then, some manufacturer, bent on new product development or old product improvement, shoots a question at us, "What about this E-C glass of yours?"

We're always glad to tell people what we know that's pertinent to their problems. And we'll be glad to tell you, too, if you're interested. Just check the E-C square in the coupon below.

glass gun

Nobody would have believed five years ago that a gun made of glass could shoot anything, but today the oil industry is using glass guns to shoot holes in heavy steel oil well casings to release trapped oil pools miles deep in the ground, making run-out wells produce profitably again and even bringing some dry holes to life.

These guns are called glass jet perforators. They contain shaped explosive charges and a 4-inch charge will cut a neat hole through six inches of steel without leaving even a burr.

McCullough Tool Company of Houston, Texas, was far from happy with the containers for their shaped charges. After considerable experimenting with various metal containers, McCullough asked, could we design and manufacture a glass container that would stand the tremendous pressures involved, but completely disintegrate after the charge exploded? (Metal containers left debris in the well which often clogged valves and pumps.)

Up to thirty or forty glass jet perforators are mounted in series on a metal strip for lowering into oil well casing.

How we found the answer in PYREX heat-resisting glass perforators may interest you even if you don't own an oil well. It illustrates another instance where we were able to help a customer find a successful answer to a design and engineering materials problem.

▼ An article in the October-November 1953 Corning GLASSMAKER tells the story in detail. Just check the appropriate square on the coupon below and we'll be glad to send you a copy.

solving problems

If you've been wrestling with a materials problem that still refuses to lie down long enough for the count, we encourage you to thumb a few informative pages that describe briefly and succinctly some of the things other people are doing today with glass.

In a matter of only a few decades glass has changed from a simple, fragile material of limited utility into a versatile material whose uses are unnumbered. You'll glimpse something of the meaning of this conversion by remembering that glass can now be made as light as cork or heavier than iron, hard as steel or soft as cotton, thin as tissue or thick as a wall; that it can be fragile or strong, a conductor of electricity or an insulator, a selective transmitter or absorber of radiation in the infrared or the visible, the ultraviolet or the X-ray regions of the spectrum, *as required*.

There may be an idea or two for you in these 48 pages of informative but nontechnical reading about some of the things people are doing these days with glass.

▼ This parade of antithetical utilities roughly indicates the flexibility and versatility of modern glass. If any of them suggest a possible answer to that stubborn problem of yours and you'd like to modernize your information about glass, quite painlessly, the few pages we mentioned three paragraphs ago make up an illustrated booklet we'd like to send you. Just make your mark in the "Glass and You" square and mail the coupon to us.

If the items covered on this page don't seem to bear on any problem of yours, we may have the information you need at our fingertips. We'd like to hear from you.
▼

CORNING GLASS WORKS
CORNING, N. Y.

Corning means research in Glass

CORNING GLASS WORKS, 10-4 Crystal Street, Corning, N. Y.

Please send me more information about E-C glass ☐; a copy of the Oct.-Nov. '53 GLASSMAKER article ☐; "Glass and You" ☐.

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COMPANY _____

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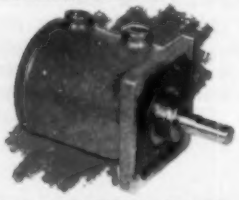
It's No Coincidence That
TowmoTorque Control
is Oil Powered by
HYDRECO

Advanced engineering ideas, like the Towmotor TowmoTorque drive, have joined forces with HYDRECO Oil Power too consistently to be a coincidence.

Of interest to design engineers is the hydraulics problem successfully solved here. The control of the torque converter drive through a specially-designed HYDRECO valve enables the operator to control vehicle speed independently of the hoisting speed. For example, the operator can drive the truck forward and backward very slowly while raising the load at maximum speed. Other HYDRECO components on this truck include a special cylinder and relief valve for the TowmoTorque, and a pump, control valve and cylinder for the hoist circuit.

HYDRECO Oil Power is providing a definite sales advantage to more and more makes and models of mobile equipment, machine tools and special machinery. And, frequently you'll find that the things you're dreaming up are problems already solved by HYDRECO engineers.

The famous HYDRECO Four-Bolt design gear-type Pump for 1000 to 1500 psi applications is the heart of the Towmotor hoist circuit.



A compact HYDRECO cylinder designed with low-friction characteristics actuates the TowmoTorque drive.

This HYDRECO relief valve is used on the torque converter to protect the heat exchanger from excess pressure.

Located beneath the floorboards is the HYDRECO-designed valve, one plunger of which is connected to a hand lever and hydraulically controls the forward and reverse motion of the truck. The other plunger, connected to a foot pedal, controls the vehicle speed regardless of engine speed.

Write

Write for the latest HYDRECO bulletins on Pumps, Motors, Valves and Cylinders.

HYDRECO DIVISION
THE NEW YORK AIR BRAKE COMPANY
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exist. Therefore, I was very pleased to read Mr. H. D. James' article "How to Select a Selenium Rectifier," (*Product Engineering*, Feb., 1954, p. 192).

However, there are a few points I believe require clarification. . . . First, that the 30 volt cell rating is available in commercial units. We have been using 40 volt cells for nearly two years and for industrial use only—we do not make very small rectifier units; our range is from ¼ kw to several hundred kw. And second, selenium rectifiers are commercially available that will handle up to 50 hp, 230 volt d-c motors. Our standard units are made up to 100 kw for 550 volt a-c input and 600 volt d-c output. Above that size (100 kw) our input is usually 2300 or 4160 volts, and we list up to 1,000 kw. I am sure competitive manufacturers go as high in their units as we do. I want to make this clear because the majority of people are acquainted with rectifiers only in television and radio sets, where they not only have a short life, but are also extremely small.

—SAMUEL HELLER
American Rectifier Corp.

Atomic Engineers

To the Editor:

Reference is made to your article "Wanted—Engineers for Atomic Energy," appearing in the February 1954 issue of *Product Engineering*.

This is a very interesting and thought provoking article, in fact so much so that additional data is hereby requested.

As head of a very small engineering group in Government service, I have several engineers who do not have "permanent status" as termed by Civil Service criteria. Therefore, some of the individuals have been investigating other employment possibilities, particularly in the atomic energy field.

It may well be that their contacts were not directed in the right plane, but, in general, replies to their applications have been in the negative. While it can be readily understood that certain types of scientists may be more in demand than others, it would seem as if any qualified engineer, presently engaged in engineering work, would be considered as a potential employee at any atomic energy installation.

If you have available, and are per-

mitted to disclose such information, I would appreciate installations and/or individual's names to whom application may be made. This may include government service as well as private industry such as mentioned in your article. While Midwest locations are preferable, the individuals concerned would certainly consider making application for installations in other parts of the country.

It is realized that you are not in a position of running an employment agency, but the undisputable fact that conditions as stated in your article are not compatible with plies to various individuals above mentioned, may be of interest and permit you to dispense this information. —E. G. GREY
Madison, Indiana

Ed—To answer your question, we suggest you get a copy of the Fifteenth Semiannual Report of the Atomic Energy Commission (available from the United States Government Printing Office, Washington, D. C.). This comprehensive progress report of the United States Atomic Energy Program lists all the companies, educational institutions and government laboratories involved in atomic energy work, what phases of work are covered, and their location. For instance, there is one section devoted to raw materials for atomic energy, including ore production and processing. Under the subject of reactor development, are listed all the companies that have explored the development of better nuclear reactors. Also in this group you will find a listing of the so-called "survey teams"—companies that have been studying the feasibility of generating electricity from atomic power on a commercial basis.

In addition to the possibilities of industry, there are many research projects at colleges and university laboratories. These are listed in Appendix 3 of the AEC Report.

Many companies not listed in the report are anxiously waiting to enter the atomic energy field. They are waiting for relaxations in the McMahon Act, which presently restricts private industry in atomic energy work. As soon as new legislation is passed—and it is included in the program submitted to Congress by President Eisenhower —many new job opportunities will open for engineers in this field.

Good hunting.

the ALL Way Balanced Dual-Vane

DUDCO

HYDRAULIC PUMP

Featuring starting torques higher than running torques, DUDCO has long been recognized as the most efficient Fluid Motor in the field. Standard models from 180 lb. in. to 14,400 lb. in.

One look at the inside of a DUDCO Pump tells the story of efficiency through *fully* balanced construction. Note how, at all times, the Dual-Vanes provide a *double* barrier to slippage and lost power. These DUDCO Vanes are individually balanced to closely follow the cam ring contour without wear-producing thrust . . . their unique displacement action provides an extra 15% to 20% added volume.

Smooth, non-pulsating DUDCO power, delivering 2000 psi for continuous operation, frequently doubles the capacity of less efficient hydraulic circuits. Standard models from 3 gpm to 120 gpm.

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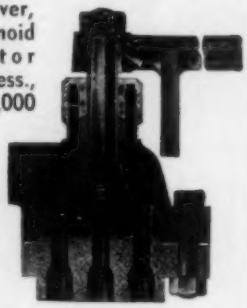
Large Processor Chooses

Nicholson Valves for LONG WEAR

A large rubber firm reports that Nicholson cylinder control valves recently completed 10 years of constant use, without servicing, on an operation which had proved too much for other tested units. This report further confirms that Nicholson valves, with their specially treated hard seats and non-corrosive lapping flat discs, become tighter with use. For air, gas, oil, steam, water in lever, foot solenoid and motor types. Press., 300 to 5,000 lbs.

Solenoid (left) and motor types, ⅛" to 2½"; pressure to 375 lbs. Foot models (above), ¼" to 1½"; press. to 300 lbs. Lever models (right) ¼" to 2½"; pressures to 5000 lbs.



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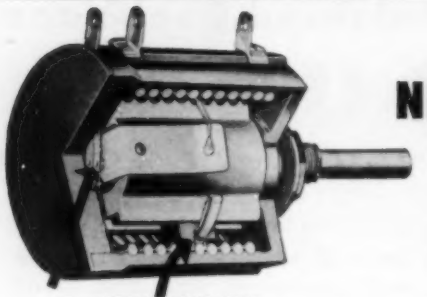

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NEY'S SMALL PARTS PLAY A BIG PART IN PRECISION INSTRUMENTS

The output of any potentiometer is dependent upon the contacts. Illustrated above is a Helipot 10-turn Potentiometer (Model A) using Ney Precious Metal Contacts between the slider and the resistance winding and for the slip ring pick-off, assuring the utmost in linearity and electrical transmission.

The J. M. Ney Company has developed a number of precious Metal Alloys and fabricates these into contacts, wipers, brushes, slip rings, commutator segments and similar components for use in electrical instruments. Ney Precious Metal Alloys have just about ideal physical and electrical properties, high resistance to tarnish, and are unaffected by corrosive atmospheres. Consult the Ney Engineering Department for assistance in selecting the right Ney Precious Metal Alloy which will improve the electrical characteristics, prolong the life and accuracy of your instrument.

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NEW BOOKS

Construction Methods and Machinery

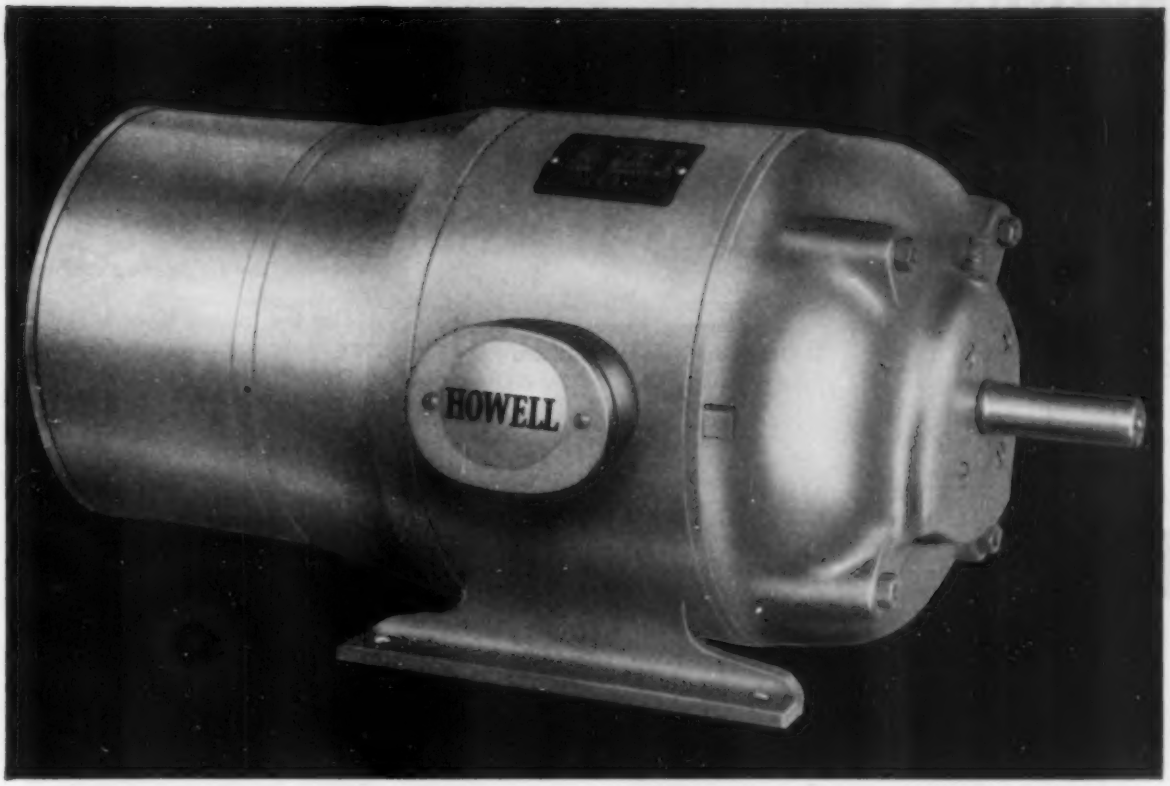
F. H. KELLOGG, Dean, School of Engineering, *University of Mississippi, Consultant, Engineering and Construction Dept., TVA.* 6 x 9 *in.*, 415 *pp. Published by Prentice-Hall, Inc.*, 70 *Fifth Ave., New York* 11, *N. Y.* $10.

Construction is, next to agriculture, the largest industry in the United States. It has, however, lagged behind the manufacturing industries in mechanization, in applications of the principles of scientific management, and, in general, in producing at low cost for mass production.

This book is an attempt to bridge the gap between construction methods and a scientific method of approach to provide for low cost mass production in the construction field. It is the desire of the author, who is eminently qualified, to present a phase of civil engineering that can serve the construction field, much in the way that the industrial field in mechanical engineering serves manufacturing.

A further attempt has been made to bridge the gap between the predominately deductive reasoning of the engineering school and the predominately inductive reasoning of construction practice. Although a quantitative approach has been used so far as practicable, the reader is left to make his own assumptions, to collect his own data, and to select the necessary data from a mass of available facts. He is taken away from the familiar problems which have only one possible correct answer, and introduced to those which have, at best, only a most probable answer. He is taken beyond the fields of statistics to which civil engineering has been so largely restricted, and shown practical applications of other major engineering fields to general construction. It is hoped that he is shown the difference between the engineer and the scientist, through demonstration of the dominantly economic nature of the problems of practice.

The author uses the process chart of industrial engineering to help visualize and plan construction operations, to compare methods in building excavation, rock excavation, and con-



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For sudden stopping, quickly and surely—there's a Howell Brake Motor that fits your exact needs!

The Howell Brake Motor is designed for use in those applications where rapid stopping of rotation is required. Howell Brake Motors are used extensively on such machines as lathes, planers, drill presses and dumbwaiters.

Quick stoppage can be accomplished on motors of all types in most sizes. Brakes are of standard construction for long life and trouble-free operation.

Howell Disc Brakes are integrally mounted, simple in design, easily accessible and quickly adjusted. For complete details on using Howell Brake Motors in your operation, contact the Howell man in your area, or write the factory for Bulletin BR-1 and further information.

Three types of Howell Brake Motors

Howell General Purpose, Dripproof, Horizontal Motor (Type SC) for wall mounting, with integrally-mounted disc brake.

Howell Vertical Face-Mounted Motor with 50 ft.-lb. brake. Howell Brake Motors fit a wide variety of applications.

Howell Special Horizontal Flange-Mounted Pancake Motor with 3 ft.-lb. brake. This streamlined motor is unusually compact.

HOWELL Red Bond MOTORS

HOWELL MOTORS

HOWELL ELECTRIC MOTORS COMPANY, HOWELL, MICHIGAN

PRECISION-BUILT MOTORS FOR INDUSTRY SINCE 1915

SKINNER EXPLOSION-PROOF

stainless steel solenoid valves

Underwriters' Approved For Class 1, Group D, Hazardous Locations

X5 SERIES

Extremely flexible design makes the small Skinner X5 Series the *most versatile explosion-proof valve on the market!*

X5 Series Valves are inexpensive, yet built to highest quality standards. Rugged, stainless steel construction, simplicity of design (only one moving part) and spring-loaded plungers with positive-sealing synthetic inserts contribute to trouble-free operation — through *millions of cycles.*

Skinner X5 Series Valves can be easily disassembled and inspected without removal from the line.

X5 Series Valves are available in a broad selection of types, voltages, pressures, flow control adjustments, port sizes and port locations.

TYPE X5 SPECIFICATIONS

Type	Two-Way and Three-Way, Normally Open, Normally Closed, and Directional Control
Pressure Range	0-1000 p.s.i.
Orifice Diameter	3/64" to 1/4"
Pipe Size	1/8" or 1/4" NPT
Voltage	All AC and DC
Power Consumption	10 Watts Max.
Duty Cycle	Continuous or Intermittent

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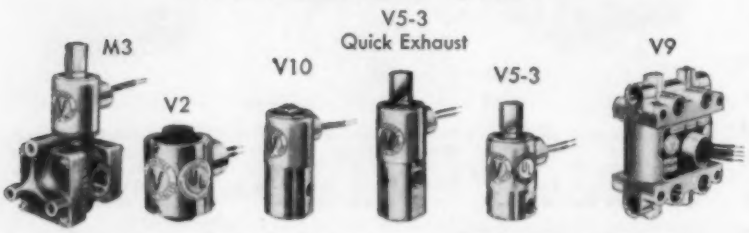
TYPICAL SKINNER VALVES

Write for information about our complete line.



SKINNER ELECTRIC VALVES — SOLENOID VALVES

THE SKINNER CHUCK COMPANY

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crete making. He has adapted and done special research on time studies and interpretation of performance data, treating them statistically to give a rational relationship to costs. Time-saving graphical methods also are presented for calculating storage capacity, balancing of excavation and hauling equipment, and for batching computations.

The first chapter gives a general view of the organization and planning required in construction. Then there follows quantitative applications of economics and statistics to fit planning, estimating, selection of equipment and cost control. Chapter Four discusses the interpretation of manufacturers' specifications in determining power requirements. Basic principles of construction transportation and their application in choosing transportation equipment is given in Chapter Five, and in the same manner, hoisting, conveying, and pumping equipment are treated.

The above principles are then quantitatively applied to construction operations in the field. Specific operations are discussed in the order in which they would normally be scheduled in a project with the help of flow charts and statics. They include clearing and grubbing, earth and rock excavation foundation treatment, aggregate and concrete, and structural erection.

The last seven chapters are largely quantitative and every major topic is illustrated by an example.

Introduction to Electric Fields

WALTER E. ROGERS, *Assoc. Prof. of Electrical Engrg., University of Washington.* 6 x 9 *in.*, 333 *pp. Published by McGraw-Hill Book Co., Inc.*, 330 *West* 42 *St., New York* 36, *N. Y.* $7.50.

This book serves two purposes: first, it presents Maxwell's equations as a logical summary of some truly analytical experience in solving the problems of electric and magnetic fields by vector methods; and secondly, it provides an introduction to potential theory and boundary-value problems at a level substantial enough to form a foundation for the concept of vector potential.

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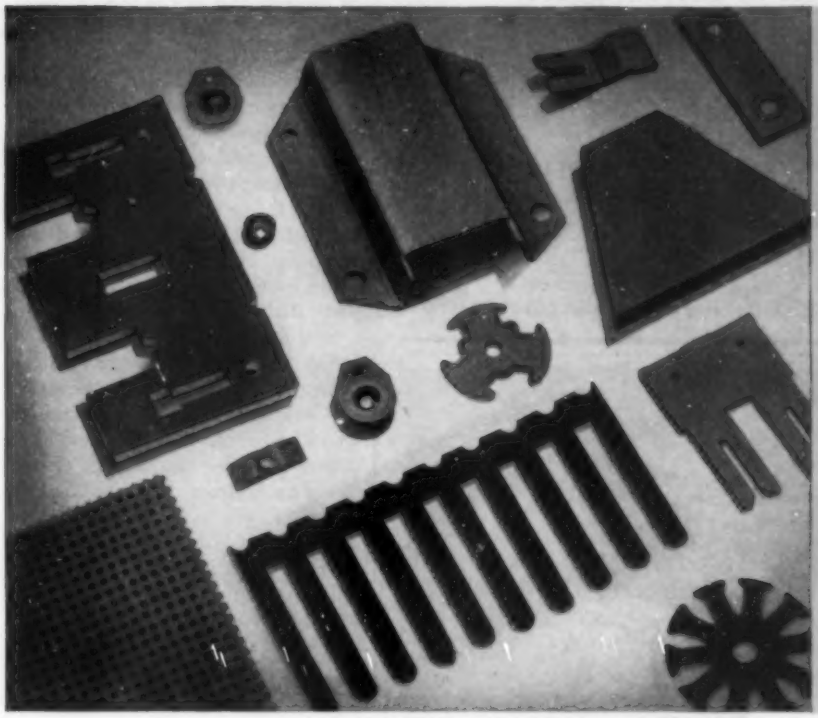

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senior electrical engineers, the book is suitable for power and communication majors. Treatment is at an intermediate level . . . above the basic type of text which does not use vector analysis, but at a lower mathematical level than comprehensive texts intended for graduate students. Basic concepts are treated in detail and are accompanied by physical interpretations in terms of the student's previous experience.

The book is well integrated and organized, and carefully written as regards symbols and notations. New concepts are introduced gradually with time for examination of several facets of the new idea and method of thinking. A. D. Moore's recently developed fluid-mapping methods are used extensively as illustrations and as an aid to visualization. The author's new method of portraying potential contours on membrane analog is used in the same way. Though limited to the simpler aspects, the treatment of vector potential contains a number of three-dimensional figures and aids to visualization which have not been treated elsewhere, particularly in introductory books.

Specifically, the chapters contain the following material: vector analysis, electrostatic fields from the viewpoint of Coulomb's Law, potential and potential gradient, the electric field in current-carrying conductors, electrostatic fields from the viewpoint of Gauss's Law, the method of images, dielectrics and insulation, divergence and the equations of Poisson and LaPlace, the magnetostatic field, time-varying electric and magnetic fields and vector potential.

Formulas for Stress and Strain

RAYMOND J. ROARK, Prof. of Mechanics, the University of Wisconsin. *6 x 9 in., 381 pp. Published by the McGraw-Hill Book Co., Inc., 330 W. 42 St., New York, 36, N. Y.* $7.50.

This is the third edition of a book whose purpose is to make available a compact, adequate summary of the formulas, facts and principles pertaining to strength of materials. The success of previous editions indicates that it is useful both as a handbook for engineers who are concerned with machine and structural design and as an

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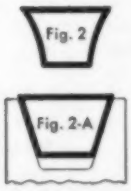

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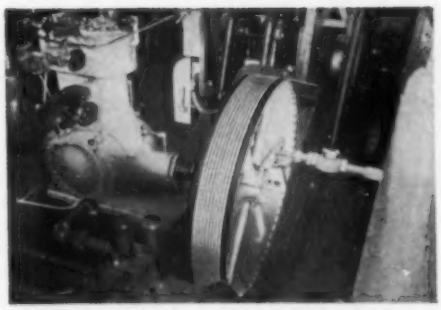

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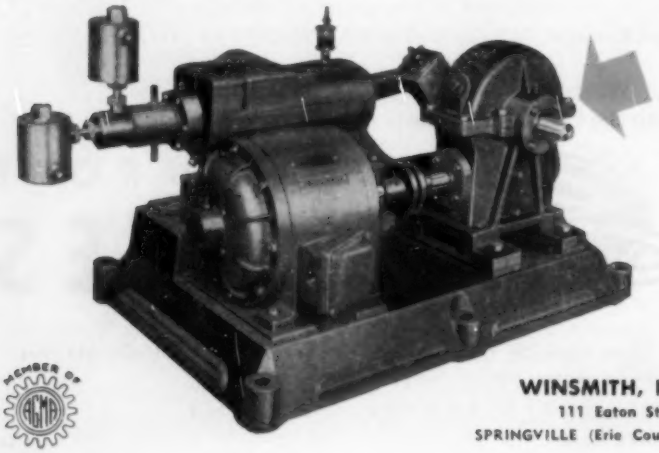

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auxiliary textbook for courses in stress analysis and elasticity.

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The chapters are headed as follows: (1) Definitions; (2) Symbols and Units; (3) The Behavior of Bodies under Stress; (4) Principles and Analytical Methods; (5) Experimental Methods; (6) Properties of a Plane Area; (7) Tension, Compression, Shear and Combined Stress; (8) Beams, Flexture of Straight and Curved Bars; (9) Torsion; (10) Flat Plates; (11) Columns and Other Compression Members; (12) Pressure Vessels, Pipes; (13) Bodies under Direct Bearing and Shear Stress; (14) Elastic Stability; (15) Dynamic and Temperature Stresses.

Magnetic-Amplifier Circuits

WILLIAM A. GEYGER, *Magnetics Div., U. S. Naval Ordnance Lab.* 6 x 9 *in.*, 277 *pp. Published by McGraw-Hill Book Co., Inc.*, 330 *West* 42 *St., New York* 36, *N. Y.* $6.

This book presents a practical treatment of the fundamental principles, characteristics and applications of magnetic-amplifier circuits. It develops logically the various kinds of basic and more complex circuit arrangements, emphasizing experimentally observed phenomena and avoiding extended mathematical considerations and cumbersome proofs. Mostly, it uses descriptive and graphical methods to give a qualitative and quantitative interpretation of the essential facts.

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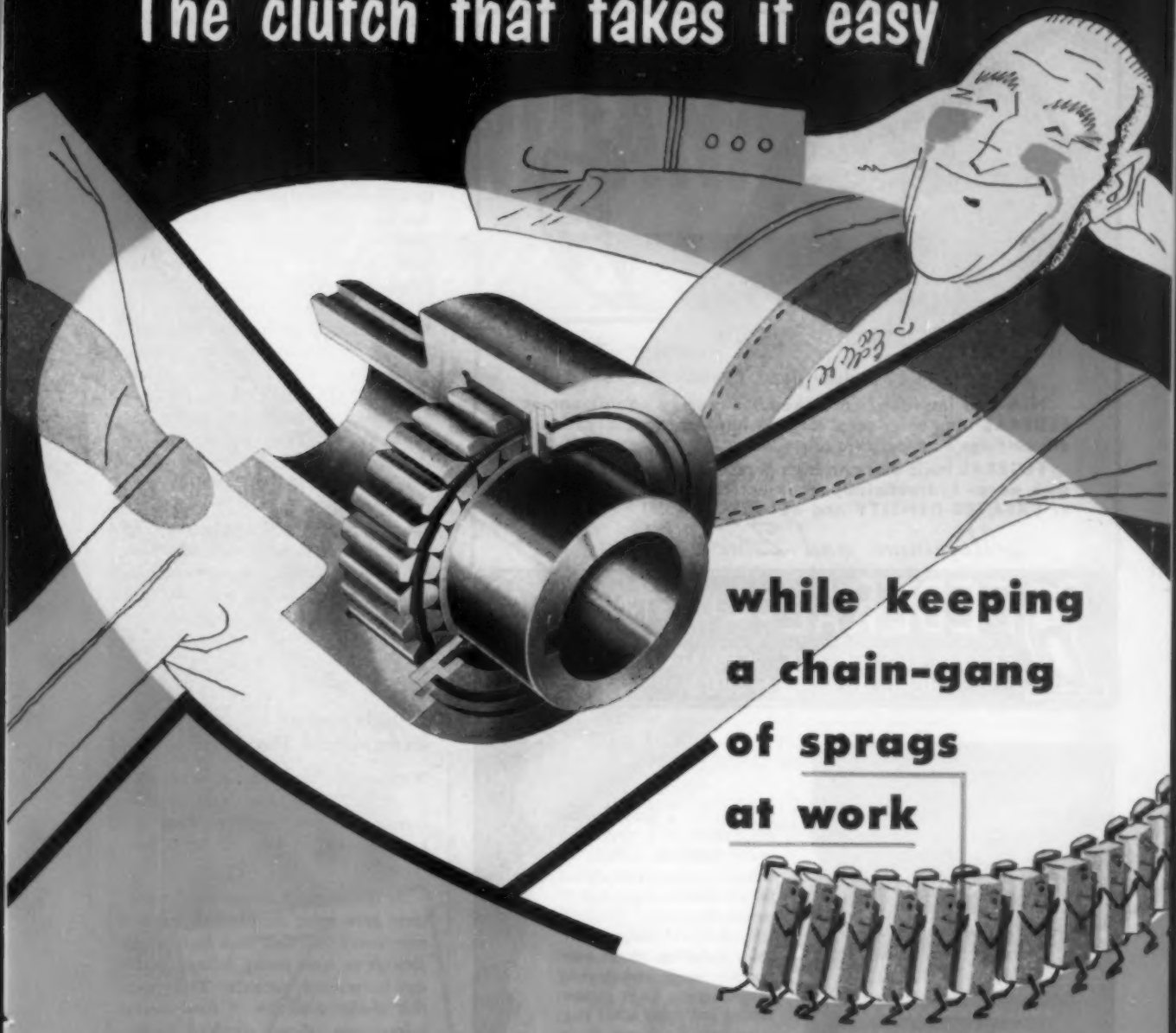

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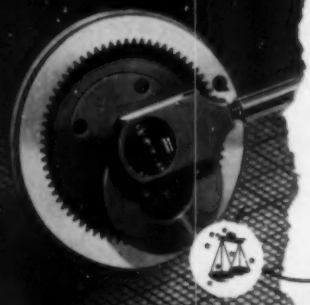

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Chapter XVII and XVIII discuss the technical properties, transient response, and typical applications of magnetic amplifiers, particularly those in instrumentation, in servomechanisms, in regulators and automatic control devices and in electronic arrangements.

Introduction to Experimental Physics

WILLIAM B. FRETTER, *Associate Professor of Physics, University of California.* 6 x 9 *in.*, 349 *pp. Published by Prentice-Hall, Inc.,* 70 *Fifth Ave., New York* 11, *N. Y.* $9.

As laboratory techniques and equipment grow more complicated, research supervisors find that it is increasingly difficult to start young college graduates on research projects. Tyros must first absorb a wealth of fundamental information about standard instruments and basic methods.

To meet this problem—at a time when there's an acuate shortage of well-trained researchers—some colleges have started courses in techniques of experimental physics. This book grew out of such a course instituted at the University of California. Compiled from lecture notes, the text aims primarily at building a vocabulary in experimental physics for the reader. And by putting all the material in one source, it enables a novice to accrue the advantages of such a course without necessarily enrolling for the lectures.

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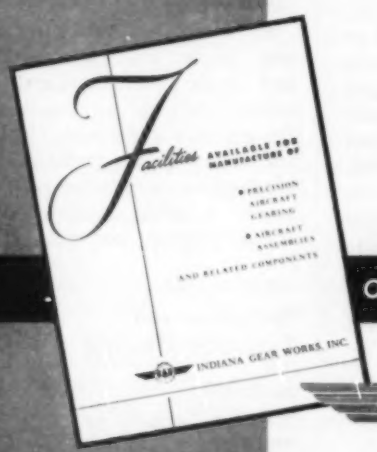
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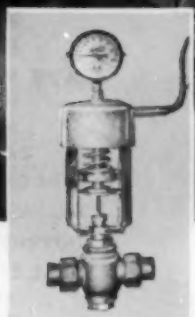

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the existing knowledge of experimental physics would require many volumes. So, Professor Fretter has concentrated his efforts on "tricks of the trade" which rarely appear in scientific journals. Much of the material is devoted to subjects in nuclear and atomic physics because it is in these fields that techniques have developed most quickly and with the highest degree of sophistication. In addition, today, the majority of physics graduates enter projects that fall under these categories.

Basically, the text covers fundamental measuring techniques, basic instruments and a small group of miscellaneous subjects like low temperature work, laboratory hazards and designing experiments.

There are separate chapters on electric and magnetic measurements. Four chapters cover various fields of spectroscopy: mass, beta-ray, optical and microwave. And there are discussions of related studies like molecular beams and X-ray diffraction techniques.

However, the bulk of the book describes various basic experimental instruments: electronic equipment like vacuum tubes, amplifiers, pulse circuits, rectifiers, power supplies and oscillators; vacuum techniques and equipment; nuclear particle counters including ionization chambers, proportional counters, geiger counters, scintillation counters and cloud chambers; atom smashers—electrostatic accelerators, linear accelerators, cyclotrons and circular electron accelerators.

Since the book is primarily written for graduate students in physics, the author expects the reader to have a fundamental knowledge of mathematics, including calculus, electronics and intermediate courses.

Induction and Dielectric Heating

J. WESLEY CABLE, *Consultant Engineer.* 6 x 9 *in.*, 576 *pp. Published by Reinhold Publishing Corp.*, 330 *West* 42 *St., New York* 36, *N. Y.* $12.50.

This valuable book offers a carefully organized treatment of the latest uses and applications of high-frequency heating in industry. Divided into two major sections, dealing with induction and dielectric heating respectively, the book contains sufficient theory to

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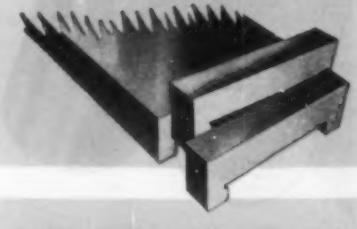

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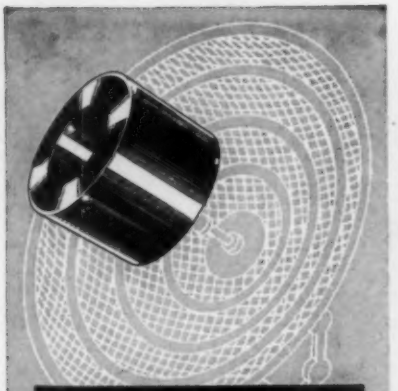

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Subsequent chapters divide the subject into specific applications: forging, melting, brazing, hardening and other metal working operations in which induction heating plays a part; and to the fields of plastics, woodworking, food processing and others in which dielectric heating finds application.

Cable's book, with its amazing range of practical information on these cost-saving processing methods, will prove invaluable to all metallurgists and to engineers engaged in production, research and design. It will also prove of special help to executives in the numerous industries wherein high-frequency heating could be used to solve specific processing problems.

Differential Equations In Engineering Problems

MARIO G. SALVADORI, *Professor of Civil Engineering, Columbia University, and* RALPH R. SCHWARTZ, *Associate Professor of Electric Engineering, Columbia University.* 6 x 9 *in.*, 432 *pp. Published by Prentice-Hall, Inc., 70 Fifth Ave., New York* 11, *N. Y.* $8.65.

In this new book, the whole subject of differential equations is considered a tool in the solutions of engineering problems, rather than a topic of interest in itself. While enough theory is given to show the logical development of the subject, the greatest amount of emphasis is placed throughout on setting up equations to represent given physical problems.

Taking up the material in order of difficulty, the authors begin with a thorough and detailed treatment of fundamentals. This solid background enables you to proceed more readily through the more advanced chapters which follow.

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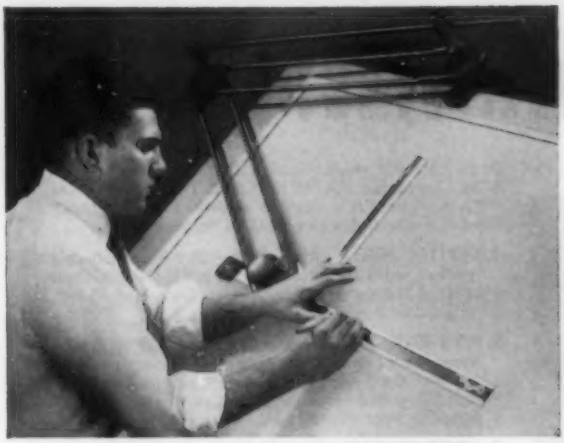

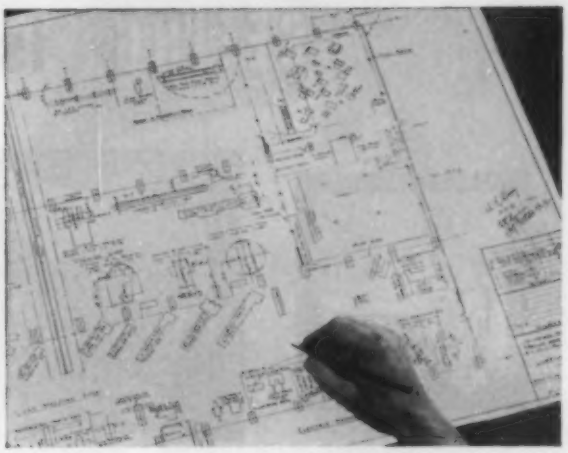

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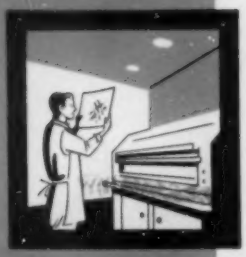

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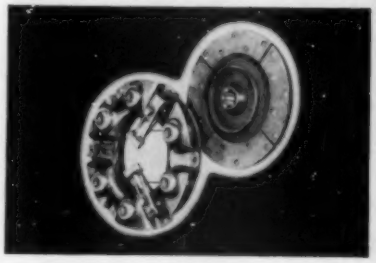

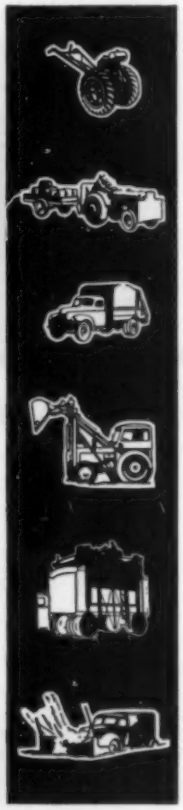

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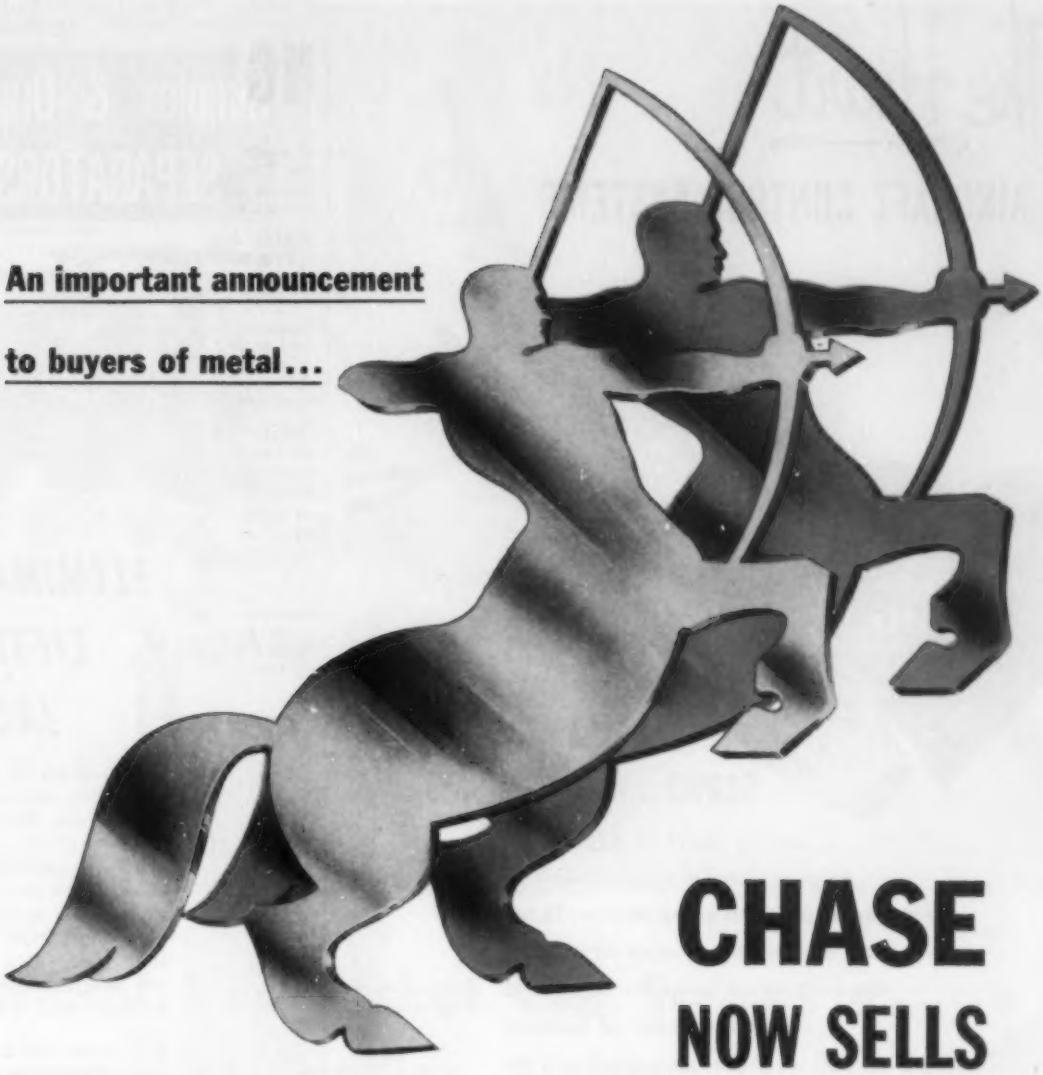
Borg-Warner Corporation
309 Catharine Street, Rockford, Illinois

ROCKFORD CLUTCHES

An important announcement

to buyers of metal...



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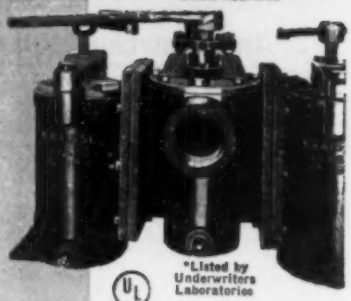

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Kraissl Class 72 duplex separators are designed so that you don't need to use a lifting jack to raise the rotary plug valve. The valves are designed to a sufficiently wide angle taper — so that the plug does not wedge on its seat, through wear and use.

Grit, scale and extraneous abrasive matter settle on the seat face, from using a lifting jack. Then, when the plug is returned to its seat and the valve rotated, the seat is galled and scored. This terminates the serviceable life of your separators —and skyrockets your maintenance and overhaul costs.

Complete range of sizes — from 1¼" to 6"; pressures to 500 psi. Cast-iron, bronze, steel, stainless-steel, also aluminum, monel or special metals to your specifications.

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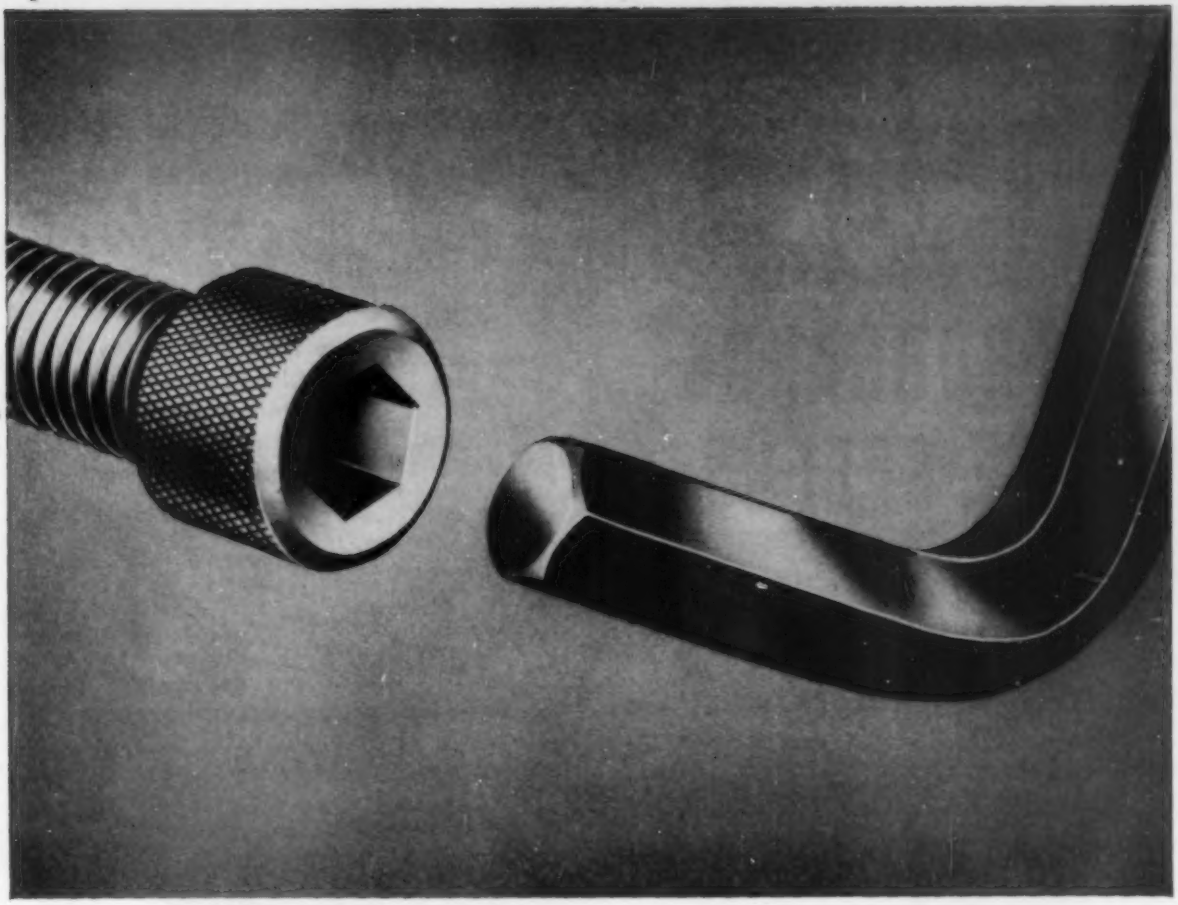

Bristol Hex Socket Cap Screws assure speedier, easier, tighter fastening

Bristol hex socket cap screws meet every production and maintenance requirement.

They spin easily into place, fit perfectly, and wrench up tightly, even in hard-to-get-at places. They take the wrench without skidding, too, so there's no danger of marring surfaces. Disassembly is just as easy. And Bristol's hex socket screws can be tightened far beyond the point where shock or vibration will loosen them.

This extra holding power results from the hex socket design, and Bristol's careful control over materials and manufacturing methods. Standard hex socket cap screws are made of alloy steel specially hardened. Other special metals and finishes may also be supplied. All Bristol screws are A.S.A. approved and precision threaded either National Coarse or National Fine.

Ask for Bristol hex socket cap or set screws in sizes from 0 wire to one inch in diameter at your industrial distributor's.

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THE BRISTOL COMPANY, Socket Screw Division, Waterbury 20, Conn.

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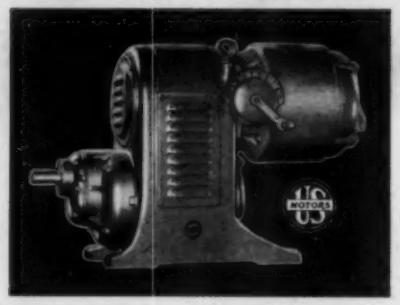

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Get more production out of your present machines by powering them with U. S. Varidrive motors. No extra space required. Thousands of plants are profiting with this miracle motor. Turning a simple control handle changes speed of the Varidrive to any desired r.p.m. in ratios up to 10:1. Operators can instantly select the speed best suited for the work.

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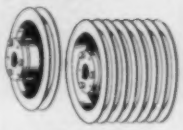

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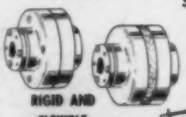

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NEW SEAL PROGRAM AVAILABLE TO FABRICATORS

Aluminum Pigments Offer Variety of Finishes . . . Add Beauty and Protection

Polychromatic finishes give designers a new flexibility of design. The sparkling flakes of Reynolds "non-leafing" aluminum pigments added to colored lacquers and enamels give products a lasting beauty, depth and iridescence that enhance their appearance. And it doesn't matter whether the product is made of metal, plywood, plastic, composition, or wood—polychromatic finishes beautify and protect any solid surface.

Wrinkled

Reynolds special patented process eliminates the normal leafing characteristic of aluminum pigments. As a polychromatic finish sets up, the aluminum pigment remains evenly dispersed in the lacquer or enamel to catch light beneath the surface, thus providing depth and sparkling beauty as well as a durable, protective surface. This is true of all three types of polychromatic finishes made with Reynolds "non-leafing" aluminum pigments—Regular, Hammered and Wrinkled.

Regular

These fine finishes are perfect for a wide variety of products. Regular for: cars, trucks, gasoline station pumps, etc. Hammered for: lawnmowers, vacuum cleaners, compressor housings, thermos jugs, etc. Wrinkled for: typewriters, business machines, air conditioners, etc.

Hammered

For names of polychromatic finishes manufacturers and a copy of the free brochure, "Industrial Polychromatic Finishes," contact the Reynolds Office listed under "Aluminum" in your classified telephone directory. Or write the Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

"Designed in Reynolds Aluminum" Seal Offers Fabricators an Opportunity to Put Powerful Reynolds Advertising and Merchandising Support Behind Their Products

As a means of giving their fabricating customers the added benefits of millions of dollars of advertising and merchandising support, Reynolds Metals Company takes pride in announcing a new, "Designed in Reynolds Aluminum" Seal Program for fabricators who use Reynolds Aluminum in their end products.

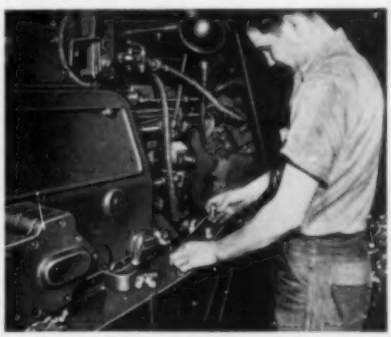
Aluminum Screw Machine Stock Gives Three Times the Number of Pieces Per Pound

Reynolds Aluminum screw machine alloys are recognized throughout industry as having exceptionally good machinability. For this reason more and more manufacturers are relying on Reynolds as their source of supply.

Aluminum screw machine stock has many advantages . . . it gives three times the number of pieces per pound, it is free-machining, has good formability, is strong and corrosion resistant. Reynolds Aluminum machining alloys are available in both bar and rod.

If you have design or production problems take advantage of Reynolds trained technical staff of aluminum specialists. They will help you get set for fast, economical production. With proper techniques and tooling methods, aluminum machining rates are limited only by the top speed of machine tools.

For prompt service, call the Reynolds Office or your nearby Reynolds Distributor, listed under "Aluminum" in your classified directory.



For the complete story on machining with aluminum send for a copy of "Machining Aluminum Alloys". Free when requested on business letterhead. Write Reynolds Metals Company, 2576 South Third Street, Louisville 1, Ky.

Because customer acceptance and identity is more vital than ever today in the "battle of the brands" the addition of the Reynolds trademark to the manufacturer's trademark offers a real chance for "Double Identity"—double impact at the consumer level at no additional cost to manufacturers who use Reynolds Aluminum.

This new "Designed in Reynolds Aluminum" Seal will be heavily promoted to millions of consumers through the popular "Mister Peepers" show Sundays on NBC TV.

National magazine advertising will reach millions more with ads telling customers to look for this new Reynolds Seal on the products they buy. Farm radio shows in 46 selected markets will also promote it. Extensive trade promotions and advertising to business leaders will also be made.

It all adds up to millions of dollars in Reynolds promotion benefiting Seal users.

Reynolds decision to offer this new program to fabricators was made after a survey of the results of the Reynolds Wrap Seal Program launched in 1953 for the benefit of food manufacturers who use Reynolds Aluminum foil in packaging their products. This program has resulted in sales advantages to participating manufacturers and indications are that this new Reynolds Seal Program for fabricators will be even more successful.

Reynolds Industrial Styling and Design Department will assist manufacturers interested in this new program with design and engineering work on their products. For details on how you and your company can qualify to participate in this great new Seal Program, simply write Reynolds Metals Company, 2576 So. Third St., Louisville 1, Kentucky.

MORE INTERESTING NEWS ABOUT ALUMINUM ON NEXT PAGE

(Advertisement)

Printed in U.S.A.

(Continued From Preceding Page)

Aluminum Powder Used in "Cold Solder"

A "cold solder" which provides the perfect coating, a hard setting putty and an excellent filling compound—all wrapped into one—for hundreds of industrial, auto body repair and homecraft uses is now being marketed under many trade names.

This product is excellent for production, maintenance and repairs requiring a coating or filler with the permanence and hardness of non-corrosive metal. It's easy to use. It may be applied with a putty knife, brushed or sprayed on as the particular item dictates. It sets up rapidly and when dry can be worked like metal—drilled, sanded, buffed, etc.

Of the three holes like that at left originally in this specimen, the center one has just been filled in with "cold solder" while the one at the right previously filled in, has now been sandpapered smooth to complete the repair.

Reynolds Aluminum Powder is an important basic ingredient in many brands of this new "cold solder." For a list of manufacturers write Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

Complete Index of All Reynolds Industrial Literature and Films Available

More than seventy-five handbooks, brochures, reprints of publication articles and nine films are listed by title, with description, in Reynolds Literature and Movie Index.

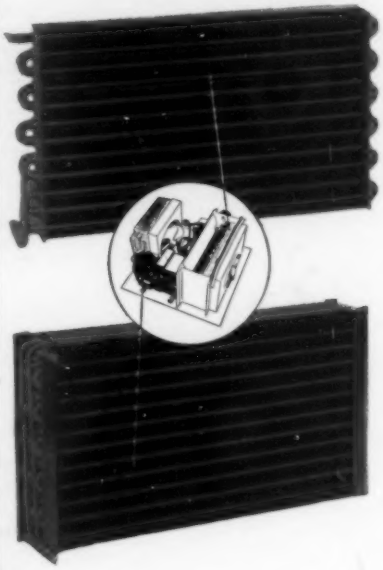
This extensive literature and film listing is conveniently grouped under the headings of Design, Fabrication, Application, Product, General and Movies so that you can quickly locate and select the material of particular interest to you.

All the helpful Reynolds literature listed in this index is available without charge. Films are also loaned free. To get your copy of Reynolds Literature and Movie Index, simply write today to Reynolds Metals Company, 2576 South Third Street, Louisville 1, Ky.

Reynolds Aluminum Fabricating Service Offers Facilities for Producing Room Air Conditioner Evaporators and Condensers

Reynolds wide experience in refrigeration, as one of the nation's leading producers of parts for this industry, has pointed up the advantages of aluminum evaporators and condensers in room air conditioners. This experience—plus Reynolds skill, mass production facilities and quality control from mine to finished product—assures production of all-aluminum evaporators and condensers to quality standards exceeding industry requirements.

All-aluminum evaporators and condensers, produced by Reynolds Aluminum Fabricating Service, assure rapid heat transfer—aluminum fins and tubes facilitate fast, economical cooling and efficient operation. All-aluminum evaporators and condensers can't rust, thus there's no danger of rust from these parts causing unsightly stains below the out-



side of the window. Tubing and fins, both of aluminum, eliminate the possibility of bimetallic action.

Aluminum's light weight aids in portability and ease of installation. Aluminum is strong—gives years of dependable service. And aluminum is economical. These aluminum advantages add up to serviceability, efficiency and economy unmatched by any other material.

Helpful literature available from Reynolds Aluminum Fabricating Service includes brochures on Appliance Parts, General Facilities and Roll Formed Shapes. For your free copy of any or all of these three brochures, simply write Reynolds Aluminum Fabricating Service, 2065 South Ninth Street, Louisville 1, Kentucky.

Lower Costs Possible for Tools, Dies and Fixtures

Tools, dies and fixtures made from Reynolds Aluminum Cast Plate and Bar have high dimensional stability and provide better performance and longer production life than other low cost stock.

The outstanding features of this revolutionary material include fine grain structure; precision machined surfaces; light weight; low cost; fast, free machining; good weldability; excellent thermal characteristics. It is available as plate up to 4″ x 48″ x 144″ and as bar up to 8″ x 8″ x 144″.

For free brochure, "Reynolds Aluminum Cast Plate and Bar for Machine Shops, Foundries and Pattern Shops," write Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

New Reynolds Plant Lifts Reduction Capacity to 829 Million Pounds

The new Reynolds Metals Company Robert P. Patterson aluminum reduction plant located in Arkadelphia, Arkansas, is now in operation. This plant, shown below, has an annual rated capacity of 110 million pounds of virgin aluminum giving Reynolds an annual production capacity of 829 million pounds.

Opening of the Robert P. Patterson plant marks another important milestone in Reynolds continued expansion in the aluminum industry. Alumina, which is converted into metallic aluminum at the Patterson plant, is supplied by Reynolds alumina plant at Hurricane Creek, Arkansas and La Quinto plant near Corpus Christi, Texas.

Bauxite for the alumina plants is mined near Bauxite, Arkansas, and at Reynolds extensive, new facilities in Jamaica.

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PUMPS, MOTORS, CONTROLS

For circuit pressures to 5000 psi

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¼" to 1" Sizes
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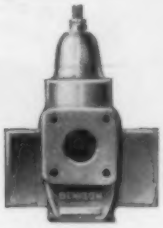
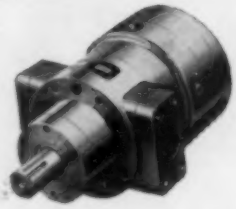
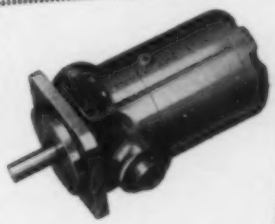


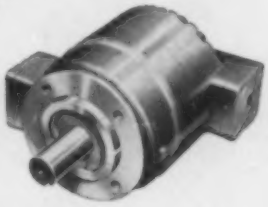
Direct-Operating PRESSURE CONTROLS
½" to 1½" Sizes
For Pressures to 2000 psi
Catalogs VRD-1 through VRD-8



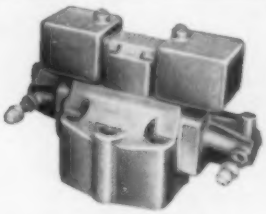
High-Pressure Axial-Piston PUMPS
Constant or Variable Volume
For 2500, 3000 and 5000 psi Circuit Needs
3.5 to 35 gpm Capacities
Catalogs P-4 through P-4-10



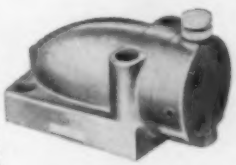
High-Torque Axial Piston FLUID MOTORS
Torque Ratings 13.8 to 112 inch-pounds per 100 psi (about 3 to 180 hp maximum)
For Pressures to 5000 psi
1500 to 3000 rpm
Catalogs FM-1, FM-2, FM-3-A



Dual-Purpose, Vane-Type PUMP/MOTOR
Ready for either pump or motor use without change
Shaft rotation in either direction
Four Sizes, 11 Models
Pumping Capacities: 3 to 82 gpm.
Motor Torque: 13 to 257 inch-pounds per 100 psi. Pressures to 2000 psi.
Bulletin P-5

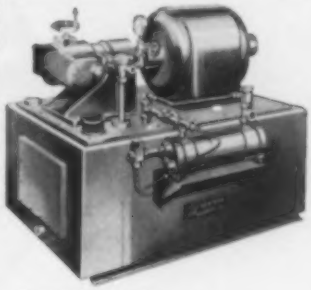


DIRECTIONAL CONTROLS
Manual, Mechanical, Electric or Pilot Control. ¼" to 2" Sizes
For Pressures to 5000 psi
Catalog VD-3



PRESSURE REDUCING VALVES
¾" to 1½" Sizes
20 gpm to 65 gpm Capacities
For Pressures to 5000 psi
Catalog VPR-1

Multi-Range FLOW CONTROLS
Full-Scale Regulation—Adjustable for Varying Input
¼" to ¾" Sizes
For Pressures to 3000 psi
Catalogs VFC-1, VFC-2



PUMPING UNITS
Constant and Variable Volume
46 Models—2 to 35 gpm Capacities
For Pressures to 5000 psi
Bulletins PU-3-A, PU-4 and PU-5

PROVED IN USE

under industry's toughest operating conditions

Denison HydrOILic Pumps, Motors and Controls are noted for their combination of high efficiency and rugged dependability.

In addition to fine performance under continuous, heavy-duty use, Denison HydrOILic Equipment offers space-saving design that simplifies circuit layout, makes installation easier, and minimizes maintenance problems.

Because so many users verify the extra value built into Denison Pumps, Motors and Controls, we continue the challenge made so often before—*let comparison prove to you* why they are first choice for so many needs of every type. Write today for full details on Denison HydrOILic Equipment to meet your requirements.

Pilot-Operated, Solenoid-Controlled DIRECTIONAL VALVES
Eliminate Spool-Sticking
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The Problem of Driving the Pump from a Reversing Shaft without Changing Direction of Flow or Port Positions

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How to lubricate reversing machinery! How to provide coolant or hydraulic power when the pump must be driven from a reversing shaft! How to insure pump flow in the proper direction on machinery which must be shipped without knowing the ultimate direction of the driving members!

The answers to questions like these are presented in this new Catalog No. 105 on Tuthill Automatic Reversing Pumps. Through a unique feature developed by Tuthill, these pumps can be driven in either direction of rotation without changing direction of flow or port positions. The wide range of types, sizes, and pressures makes these pumps readily adaptable to your requirements. Capacities up to 200 g.p.m. and pressures to 400 p.s.i.

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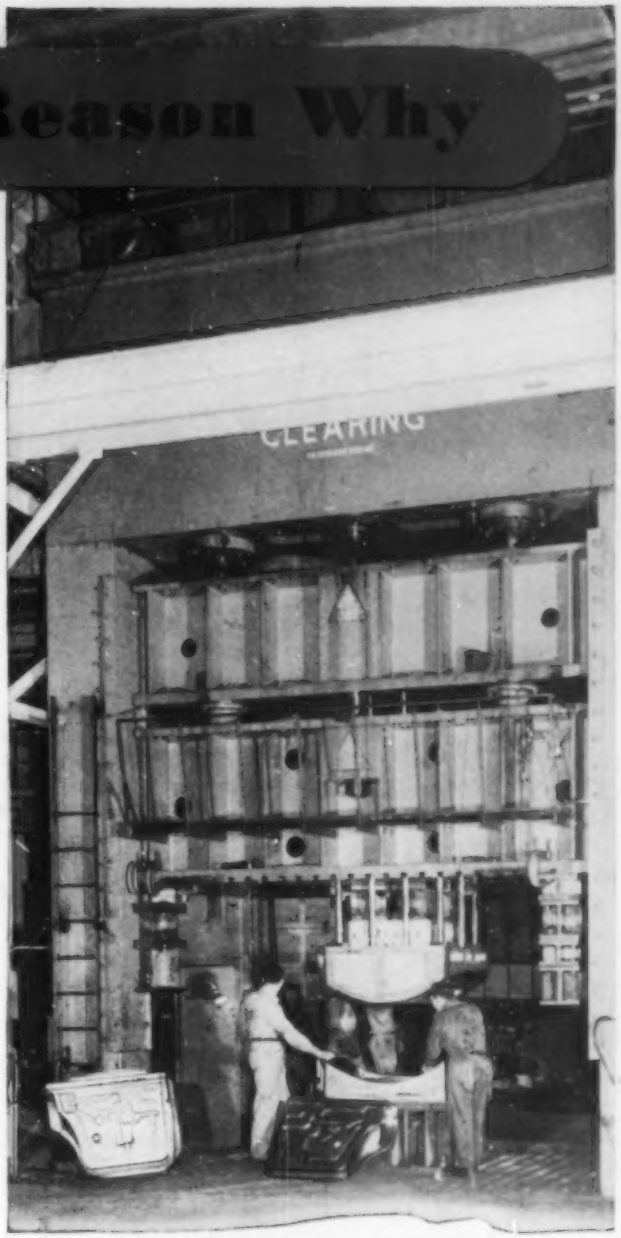

What constitutes the all-inclusive service offered by Allied's Allite Division in Hillsdale, Michigan?

Facilities include a plaster pattern shop . . . foundry and manufacturing facilities for sheet metal dies made of plastic, zinc alloy and iron . . . a wide range of press equipment . . . a fully equipped metal shop for finishing of stamped parts.

Five presses of medium-to-large capacities are utilized for tryout and for short run production of customers' parts such as those used in prototype assemblies. The largest and newest (installed during 1953) of these presses is the 1500-ton triple-action Clearing hydraulic press shown at the right. With 60-inch stroke and a bed, ram and blankholder area of 8 feet by 13 feet, it provides adequate capacity for dies up to the largest sizes.

Regardless of what your sheet metal die requirements may be—whether for a few experimental parts or for high volume production—here the finest in modern equipment and the proven abilities of experienced men are put to work for you. If you are not thoroughly familiar with the many ways in which this Allied service can save you time, money and uncertainty, we'll be happy to send you full details.

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SPECIAL COLD FORGED PARTS • STANDARD CAP SCREWS • HARDENED AND PRECISION GROUND PARTS • R-B INTERCHANGEABLE PUNCHES AND DIES

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PLANT 4
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New

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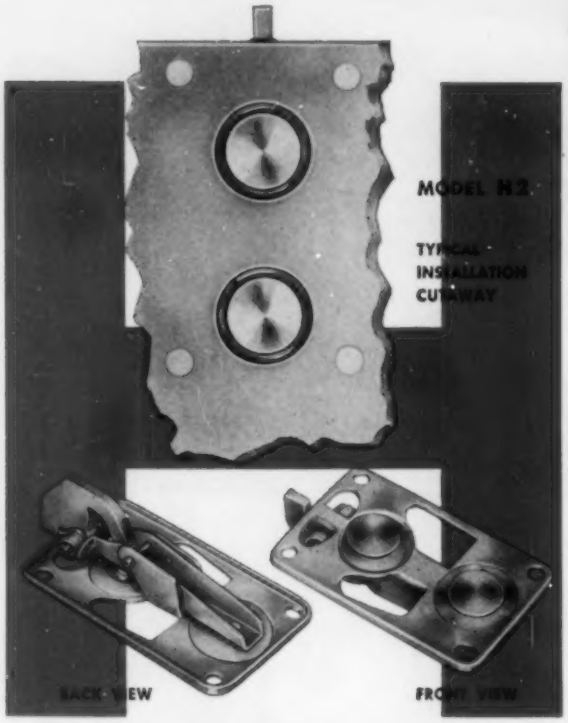
Push Button

Trigger Action

FLUSH LATCH



● A new latch development for modern equipment. Combines the desirable features of push button operation with the positive simplicity of trigger action in a small, rugged, lightweight yet inexpensive flush latch.

Available in many offset combinations for various door and frame thickness arrangements. Standard with or without gaskets in stainless steel or cadmium plated cold rolled steel.

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COMPANY

Manufacturer of Flush Latches and Hinges, Fittings and Cable Terminals.

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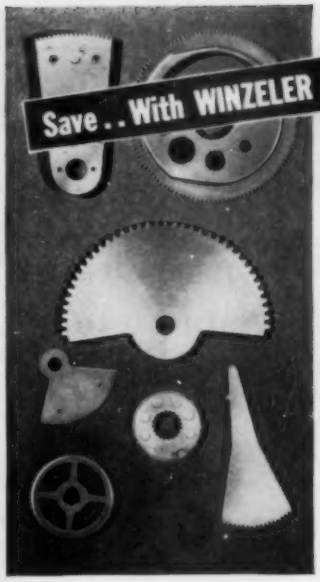

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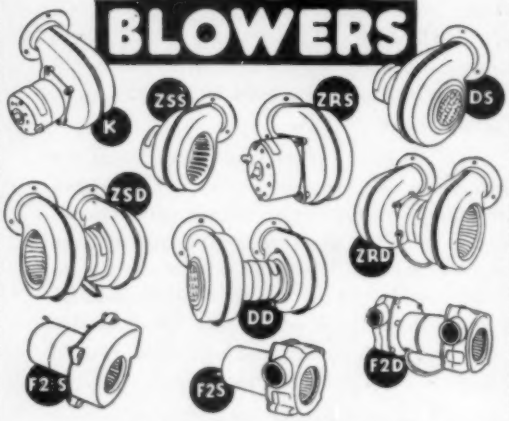

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Battery-operated for cars, trucks, boats and other portable installations.

VARIOUS MOUNTING DEVICES

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Heinze Electric Co.

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quad power unit extends advantages of

CHRYSLER *Performance and Economy to new fields*

Here's Chrysler Power at work in the South Texas oil fields. This time it is four Chrysler Model 20 Industrial V-8 Engines working together as a single unit in a Stewart & Stevenson Quad Power Unit, in turn driving a mud pump. This particular Quad has supplied mud pump power for the drilling of ten oil wells in the eight months it has been in use.

You see Stewart & Stevenson Quads in other fields, too, but nowhere do they encounter tougher jobs than pumping mud—or more important jobs either. The continued flow of mud down the hole being drilled is absolutely necessary if drilling is to continue uninterrupted. That's because mud serves several very important functions: it lubricates the drill bit, it removes bit cuttings, it seals the walls of the hole and it provides weight to prevent blowouts.

Pumping mud requires great power on a continuous basis, power that can "roll" with the heavy pulsating motion of the pump. The 331 cubic inch displacement Model 20 Engine is ideal for a multiple-engine installation. It meets the demand for high horsepower. It is a compact engine, easy to install, low in initial cost, and economical to operate and maintain. Parts are readily available, and at a fraction of the cost of competitive equipment. Each engine is supplied with a Chrysler gyrol Fluid Coupling which absorbs shock loading, thereby enabling smooth transmission of power from all four engines to the common power output shaft. One or more of the engines can be clutched out if less than maximum power is required.

Check your power needs with a Chrysler Industrial Engine Dealer. Ask him about optional equipment too. Remember, Chrysler Power is not expensive. Production-line methods adapted to specialized industrial engine building provide a custom-built engine at mass-production prices. If you prefer, write: ***Dept. 54, Industrial Engine Division, Chrysler Corporation, Trenton, Michigan.***

CHRYSLER *Industrial Engines*

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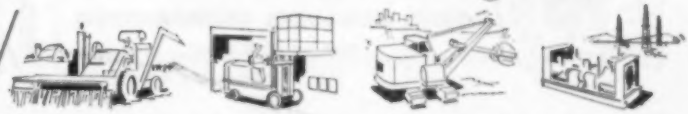

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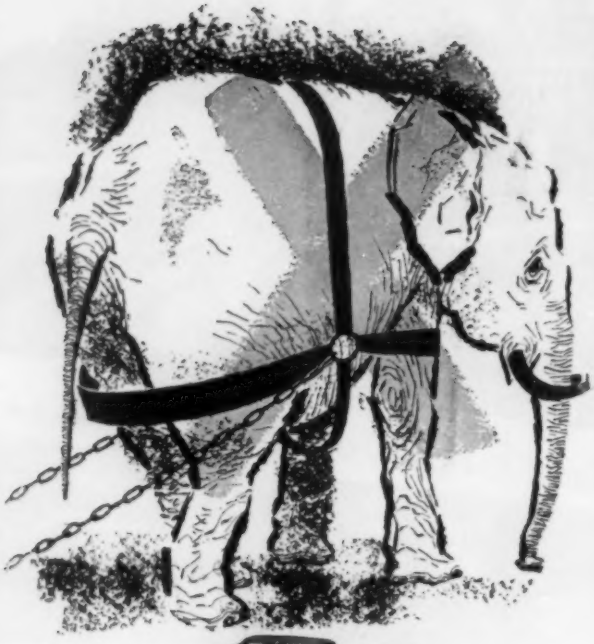

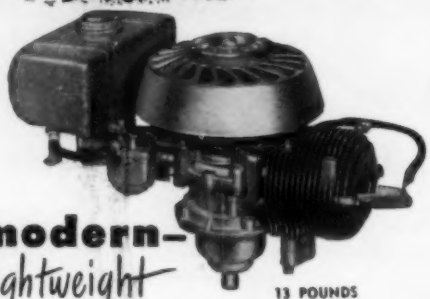

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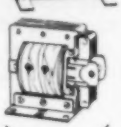

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Here's one you'll want to bite on! It's Formbrite

Upper lure is Formbrite. Lower one is made of ANACONDA Fancy Pattern Embossed Brass.

FISH find this particular line of brass spinners so attractive that fishermen's demands have built annual sales of the Aeroplane Tackle Manufacturing Company of Denver to more than two million lures of all types.

The high finish on the spinner is part of the secret. While the cost of producing this is of no interest to the fish, it is to the manufacturer. Recently all brass orders were changed to Formbrite*, the superior ANACONDA Drawing Brass that has enabled this firm to cut polishing costs over 25%, and on several stamped products to produce the required finish by tumbling only prior to lacquering or plating.

Formbrite, with its superfine grain, provides a surface far superior to ordinary drawing brass. It is stronger, harder, more scratch-resistant than ordinary brass, yet retains remarkable ductility for forming and drawing. It's a premium product at a non-premium price. If these features lure you, we should like to show you how this better brass can cut your product's finishing costs. Or write for Publication B-39 to *The American Brass Company, General Offices, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Limited, New Toronto, Ontario.*

Thirty-five years ago a fisherman, disgusted with his luck, cut up an old brass bait box to make himself a spinner resembling an old-time airplane propeller. Both fish and fisherman liked it so much, he started what is now a big and thriving business.

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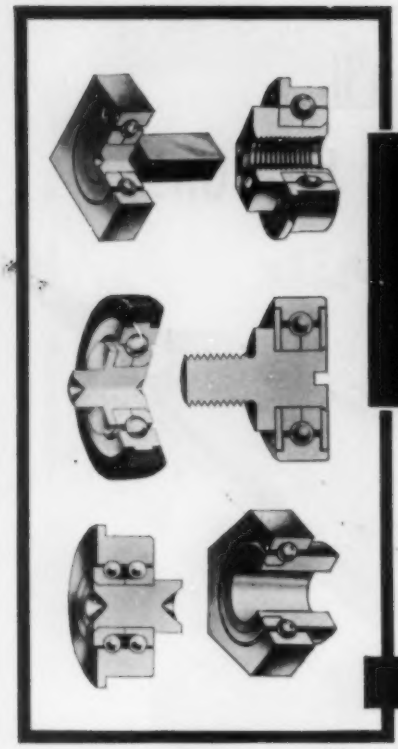
Formbrite

DRAWING BRASS

An ANACONDA® product made by The American Brass Company



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Long life and service are assured you because —

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KUSHION-TORQ

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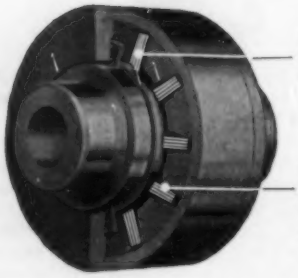


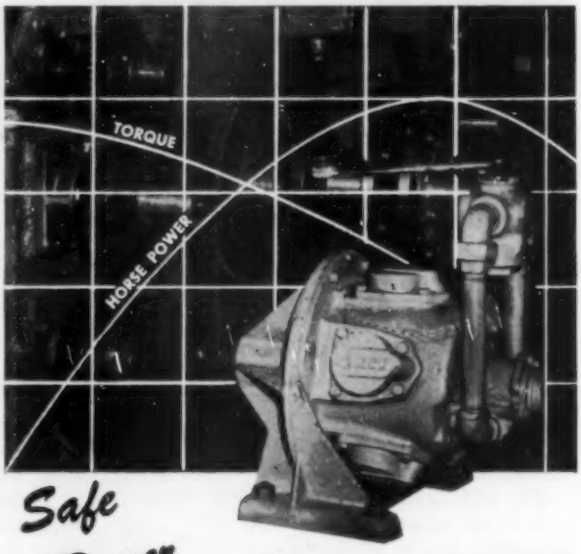
Laminated Cantilever Steel Springs transmit driving action.

Tapered slots move point of driving contact inward as loads increase to automatically stiffen cantilevers.

These Brown Coupling features mean equipment is shock and load protected - - - coupling failure is reduced - - - misalignment is corrected - - - radial and torsional vibration are dampened - - - both drive and driven units last longer.

For complete information shown in Bulletin 28P, write Brown Engineering Co., 108 N. 3rd St., Reading, Pa.

BROWN KUSHION-TORQ **COUPLINGS**



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Eimco dependable air motors provide safe power for operation in plants working with the most combustible of materials.

They are not damaged by overloads or stalling, nor is there any danger of ignition. Built in three sizes with a range from 7½-20 HP.

Available with geared reducers in a speed range from 45 to 104 RPM.

B-25

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He doesn't have to. Every piece of Phenolite laminated plastic . . . and there are literally hundreds of them in his plane . . . can be counted on to do the job it was specified to do. This versatile material performs without fail in assignments that range from insulation in passenger reading lights to gears in the automatic pilot.

What makes Phenolite's application so universal? Because there are more than 35 different grades of Phenolite manufactured as standard, and many more special types. These are based on materials such as paper, cotton cloth, asbestos paper and fabric, glass cloth, nylon, etc., scientifically compounded with phenol, melamine or silicone resins under heat and pressure. Each grade has a combination of electrical and mechanical properties that is unique. There's almost always a grade of Phenolite to give the designer—aircraft or otherwise—exactly what he wants.

What can *you* do with a material that has great mechanical strength . . . weighs half as much as aluminum . . . is extremely resistant to moisture . . . is an ideal insulator at both high and low voltages . . . can be machined, shaped, punched, sawed, drilled, worked at will . . . is resistant to heat, solvents, oils, acids, alkalis and other chemical solutions? You can use it to advantage and we'll be glad to help you.

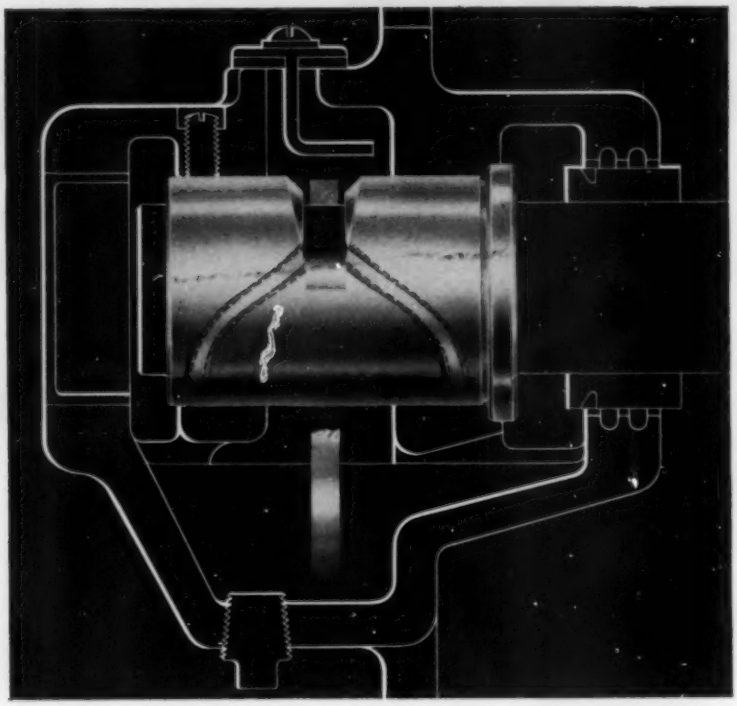
Want the facts and specifications on weights, tolerances, forms and grades available? Or dielectric strengths, colors, suggested applications, machining and forming techniques? Here's the whole story in one thumb-tabbed package. It's a catalog you can't afford to be without, so ask the National representative nearest you for your copy. He's listed in the classified directory. Or write to National Vulcanized Fibre Co., Dept. B-4, Wilmington 99, Delaware.

PHENOLITE
Laminated PLASTIC

NATIONAL
VULCANIZED FIBRE CO.
WILMINGTON 99, DELAWARE

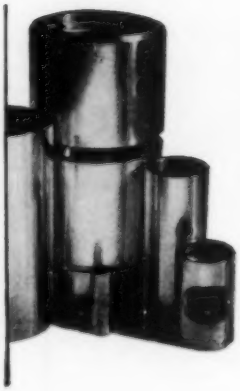
THE WAY TO CUT...

Cost of surrounding design



Although the sleeve bearing is longer than other types it is also much smaller in outside diameter. The weight of parts required to support bearings varies directly as the length of the bearing but it also varies directly as the *square* of the outside diameter of the bearing. Therefore the use of bearing types which are large in diameter and short in length frequently results in the use of surrounding parts which are unnecessarily heavy. Since unnecessary weight costs unnecessary dollars, consider the sleeve bearing not only for its own initial low cost but because of the possibility of reducing the weight and therefore the cost of the surrounding parts.

There is a Bunting Engineer near you. Consult him. Or send your inquiries direct to our Product Engineering Department at Toledo.



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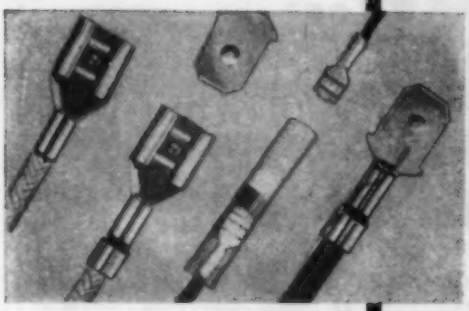
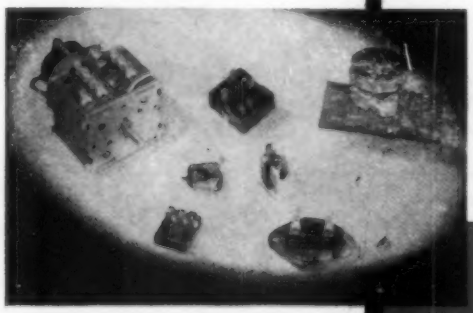
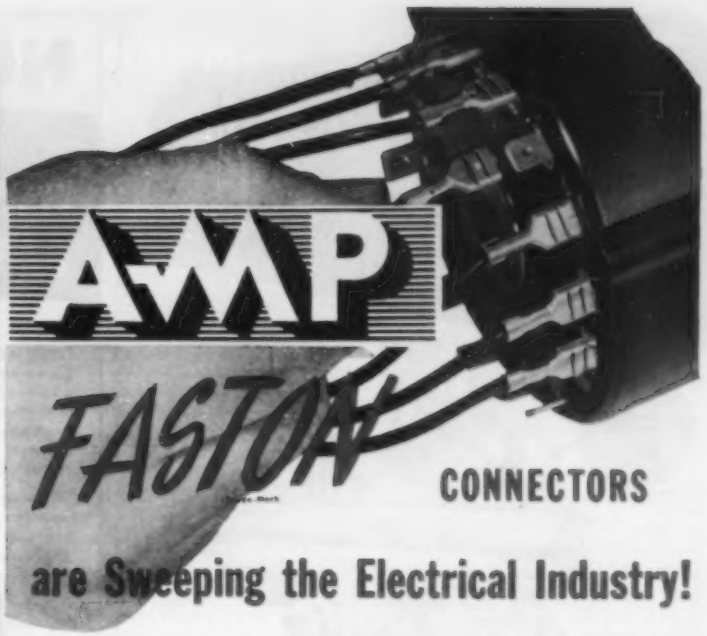


Shown above: AMP FASTON connectors with and without insulation support, FASTON insulated splice connector, FASTON TAB on wire. Also available are a wide selection of tabs for component application.

AMP FASTON connectors can be attached as fast as operator can insert wires in AMP AUTOMATIC MACHINE (up to 4,000 per hour!). Connectors are provided in strip form wound on convenient reels. Hand tools are also available.



A few of the typical appliance components adapted to receive AMP FASTON connectors. Cost is usually reduced through simplified design or elimination of binding screws, clips, etc.



CONNECTORS

are Sweeping the Electrical Industry!

More and more manufacturers are getting into the swing to AMP FASTON CONNECTORS! Timers, clocks, switches, outlets, controls—all types of electrical components when equipped with FASTON tabs not only *cost less* to produce, but offer all the advantages of easier, faster wiring on the line.

Easier and faster because AMP FASTON connectors can be applied to wires at high rates of speed (up to 4,000 per hr.). Then, to install, simply push FASTON on its mating tab. Wiring is accomplished in a fraction of the time required for screw-type terminal posts!

Triple spring action and wide wiping contact of AMP FASTON provides excellent electrical connection. U.L. approved, patented, AMP F CRIMP is voidless—gives high tensile strength and resists corrosion even under most humid conditions. Uniform, precision-engineered terminations eliminate service problems.

FASTON connectors, terminals, and splices cover all insulation ranges in wire sizes #18 through #12 A.W.G. Write today for information and samples!

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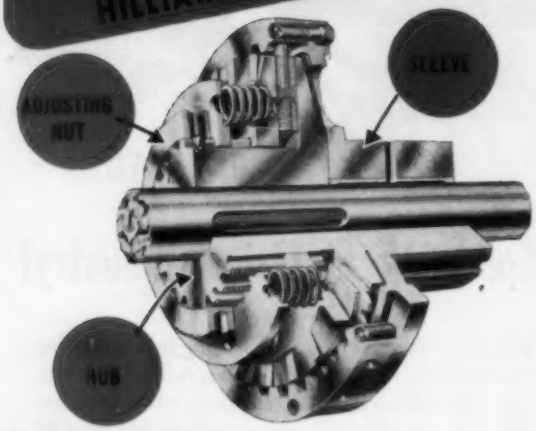
★ PROTECT YOUR MACHINERY FROM DESTRUCTIVE OVER-LOAD

★ IMPROVE THE CONTROL OF YOUR REWIND STAND WITH HILLIARD SLIP CLUTCHES



REGULAR SERIES From 50 inch pounds to 300,000 inch pounds torque. Prevents transmission of over-load. Constant torque clutches can be pre-set. *Now Available* Adjustable while running constant tension clutches. Provide ample friction surface for heavy duty use in reeling and winding operations.

THE NEW LIGHT SERIES Here's high capacity in small size. From 10 inch pounds to 500 inch pounds torque. Metallic plates, disc springs. Constant torque—easily adjustable.

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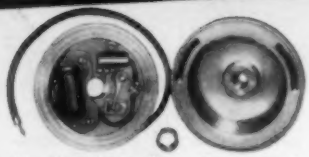
A NEW FLYWHEEL MAGNETO BY FAIRBANKS-MORSE



Small industrial engines can now be powered by Fairbanks-Morse Flywheel Magnetos—a new addition to the famous family of Fairbanks-Morse Super Spark Magnetos.

This magneto, built by the manufacturers of over 3½ million magnetos, presents a new standard in trouble-free performance and easy starting—molded heavy duty high tension coil—large, long-lasting breaker points—Alnico permanent magnets—efficient engine performance is assured.

Engineering help is yours just for the asking—personal, expert attention to your particular problem to assure top operating efficiency and easy starting of your engine is readily available. Get all the facts on Fairbanks-Morse Flywheel Magnetos plus application assistance by writing to Fairbanks, Morse & Co., Magneto Division, Beloit, Wisconsin.

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Drafting Room Furniture and Equipment

Symbol of MAYLINE Superiority

Three of many fine pieces of drafting room furniture and equipment made by Mayline. We invite your further inquiry through your local dealer or direct to factory.

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V-MODEL TABLE WITH FOOTREST

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For maximum performance specify BCA ANGULAR CONTACT BEARINGS

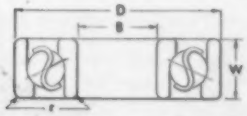
These bearings feature a sturdy one-piece, S-section retainer. There is no rivet to work loose, and the design of the retainer permits bearing construction that is fully angular-contact on both outer and inner rings. Low, medium, and high angles of contact are available in both light and medium series bearings.

BCA Angular-Contact Bearings have the ability to carry any combination of radial loads plus thrust loads in a given direction.

BCA engineering cooperation and design assistance are available to help solve your problems involving ball bearings.

The BCA Engineering Handbook is valued by engineers as an important addition to their technical library. Available to chief engineers without charge. Write on your official stationery.

DIMENSIONS AND IDENTIFICATION



Single Row—Light

Bearing Numbers Contact Angle			Bore B		Outside Diameter D		Width W		Fillet Radius* r	Balls	
Medium	Low	High	Mm.	Inches	Mm.	Inches	Mm.	Inches	Inches	No.	Size
7204-A	7204-N	7204-T	20	0.7874	47	1.8504	14	0.5512	0.040	12	3/4
7205-A	7205-N	7205-T	25	0.9843	52	2.0472	15	0.5906	0.040	11	25/32
7206-A†	7206-N†	7206-T†	30	1.1811	62	2.4409	16	0.6299	0.040	11	15/16
7207-A	7207-N	7207-T	35	1.3780	72	2.8346	17	0.6693	0.040	12	15/16
7208-A	7208-N	7208-T	40	1.5748	80	3.1496	18	0.7087	0.040	13	7/8
7209-A	7209-N	7209-T	45	1.7717	85	3.3465	19	0.7480	0.040	14	7/8
7210-A	7210-N	7210-T	50	1.9685	90	3.5433	20	0.7874	0.040	15	7/8
7211-A	7211-N	7211-T	55	2.1654	100	3.9370	21	0.8268	0.060	12	1
7212-A	7212-N	7212-T	60	2.3622	110	4.3307	22	0.8661	0.060	13	1 1/32
7213-A	7212-N	7213-T	65	2.5591	120	4.7244	23	0.9055	0.060	14	1 1/16
7214-A	7214-N	7214-T	70	2.7559	125	4.9213	24	0.9449	0.060	15	1 1/16
7215-A	7215-N	7215-T	75	2.9528	130	5.1181	25	0.9843	0.060	17	1 1/16
7216-A	7216-N	7216-T	80	3.1496	140	5.5118	26	1.0236	0.080	16	1
7217-A†	7217-N†	7217-T†	85	3.3465	150	5.9055	28	1.1024	0.080	15	1 1/16
7218-A	7218-N	7218-T	90	3.5433	160	6.2992	30	1.1811	0.080	15	1 1/16
7219-A	7219-N	7219-T	95	3.7402	170	6.6929	32	1.2598	0.080	15	1 1/16
7220-A	7220-N	7220-T	100	3.9370	180	7.0866	34	1.3386	0.080	13	1
7221-A	7221-N	7221-T	105	4.1339	190	7.4803	36	1.4173	0.080	15	1 1/16
7222-A	7222-N	7222-T	110	4.3307	200	7.8740	38	1.4961	0.080	15	1 1/16
7224-A	7224-N	7224-T	120	4.7244	215	8.4646	40	1.5748	0.080	15	1 1/16
7226-A	7226-N	7226-T	130	5.1181	230	9.0551	40	1.5748	0.100	16	1 1/4
7228-A	7228-N	7228-T	140	5.5118	250	9.8425	42	1.6535	0.100	16	1 5/16

Single Row—Medium

Bearing Numbers Contact Angle			Bore B		Outside Diameter D		Width W		Fillet Radius* r	Balls	
Medium	Low	High	Mm.	Inches	Mm.	Inches	Mm.	Inches	Inches	No.	Size
7303-A	7303-N	7303-T	17	0.6693	47	1.8504	14	0.5512	0.040	12	3/4
7304-A	7304-N	7304-T	20	0.7874	52	2.0472	15	0.5906	0.040	10	25/32
7305-A†	7305-N†	7305-T†	25	0.9843	62	2.4409	17	0.6693	0.040	10	15/16
7306-A	7306-N	7306-T	30	1.1811	72	2.8346	19	0.7480	0.040	10	15/16
7307-A	7307-N	7307-T	35	1.3780	80	3.1496	21	0.8268	0.060	10	1 1/32
7308-A	7308-N	7308-T	40	1.5748	90	3.5433	23	0.9055	0.060	10	1 1/32
7309-A	7309-N	7309-T	45	1.7717	100	3.9370	25	0.9843	0.060	11	1 1/16
7310-A	7310-N	7310-T	50	1.9685	110	4.3307	27	1.0630	0.080	12	1 1/32
7311-A†	7311-N†	7311-T†	55	2.1654	120	4.7244	29	1.1417	0.080	12	1 1/32
7312-A†	7312-N†	7312-T†	60	2.3622	130	5.1181	31	1.2205	0.080	12	1 1/4
7313-A†	7313-N†	7313-T†	65	2.5591	140	5.5118	33	1.2992	0.080	12	1 5/16
7314-A	7314-N	7314-T	70	2.7559	150	5.9055	35	1.3780	0.080	12	1
7315-A†	7315-N†	7315-T†	75	2.9528	160	6.2992	37	1.4567	0.080	12	1 1/16
7316-A†	7316-N†	7316-T†	80	3.1496	170	6.6929	39	1.5354	0.080	12	1 1/16
7317-A†	7317-N†	7317-T†	85	3.3465	180	7.0866	41	1.6142	0.100	12	1 1/16
7318-A†	7318-N†	7318-T†	90	3.5433	190	7.4803	43	1.6929	0.100	12	1 1/16
7319-A†	7319-N†	7319-T†	95	3.7402	200	7.8740	45	1.7717	0.100	12	1 1/16
7320-A†	7320-N†	7320-T†	100	3.9370	215	8.4646	47	1.8504	0.100	12	1 1/16
7321-A†	7321-N†	7321-T†	105	4.1339	225	8.8583	49	1.9291	0.100	12	1 1/16
7322-A†	7322-N†	7322-T†	110	4.3307	240	9.4488	50	1.9685	0.100	12	1 1/8

* Bearing corner radii will clear maximum fillet radius shown.
† For use of these sizes consult BCA Engineering Department.

BCA *radial, thrust, angular-contact Ball Bearings*

BEARINGS COMPANY OF AMERICA

DIVISION OF FEDERAL-MOGUL CORP.

LANCASTER • PENNSYLVANIA

marion

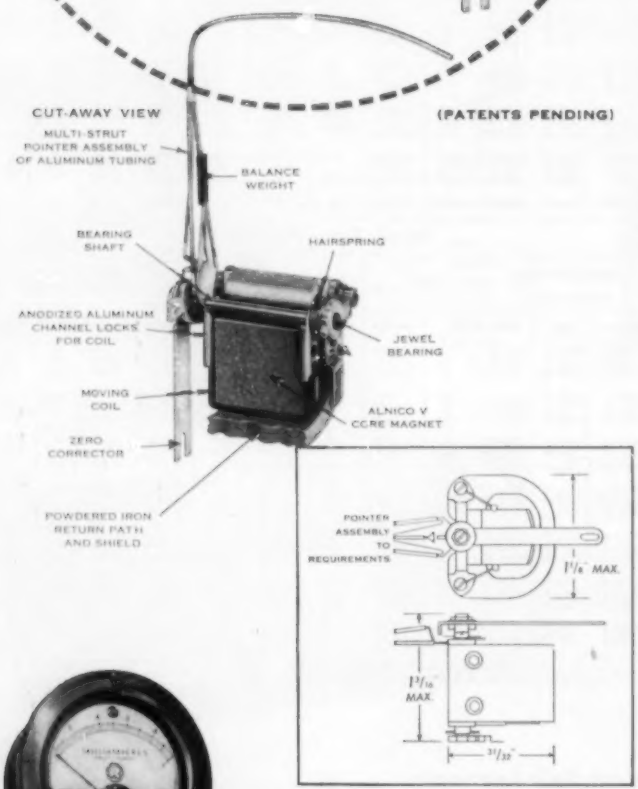
advancement in instrument design

TWO VIEWS SHOWING MECHANISM ACTUAL SIZE

POWERFUL MOVING COIL MECHANISM HAS GYRO-LIKE STABILITY

The Marion Type MEP-1 meter mechanism was designed to develop highest possible torque for a given volume of magnetic material. Its high torque, heavy eddy current damping and low relative inertia provide unusual performance characteristics simulating the stability of a gyro, in like environment. Already it is setting new and higher standards for reliability in moving coil indicating mechanism design for aircraft application, where the influence of vibration and rapid attitude changes on pointer indication are significant factors.

The gyro-like stability of the MEP-1 mechanism results from its unique mechanical design. An end-pivoted coil assembly, with a one piece bearing shaft and precise mechanical assembly operates in a self-shielded magnet structure which produces approximately 6000 Gauss in a single air gap. When the end-pivoted moving coil, of long turning radius, operates in a magnetic field of such strength, substantial gains in torque and eddy current damping are realized. This great torque, combined with relatively light weight, permits unit bearing loadings substantially lower (i. e. larger pivot and jewel radii) than heretofore normal.



MECHANISMS BY MARION

Although developed expressly for application in aircraft navigational instruments, many of the MEP-1 characteristics make it desirable for use as the sensitive element in control devices where it is required to initiate a control function. It is one of a number of Mechanisms by Marion that extend the field of moving coil mechanism application where previously size, weight or performance characteristics prevented their use.

Marion Electrical Instrument Company,
415 Canal Street, Manchester, N. H.

marion meters

Reg. U. S. Pat. Off.

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And because Rivett furnishes a complete power package—all types of air and hydraulic valves, cylinders and power units —these men can offer you a single source for all your power needs. They can plan a more efficient installation with units that have been designed to operate smoothly with each other. And knowing your complete design problem, Rivett distributors can furnish better help on maintenance, delivery and price.

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Richmond, Va. — Industrial Supply Corp., 15th & Franklin
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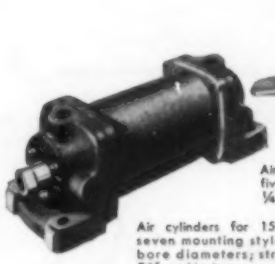
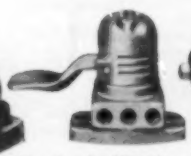
Tulsa, Okla.—John G. Burke & Co., P.O. Box 1652
Dallas, Texas — Womack Mach. Supply, 6409 Maple Ave.
Minneapolis and St. Paul, Minn.—Anderson Machine Tool Co., 2641 University Ave., St. Paul 4, Minnesota
Salt Lake City, Utah — J. M. Grisley Machine Tools, 375 S. W. Temple Street
Los Angeles, Calif. — Paul-Munroe Company, 4865 E. Gage Ave., Bell, California
San Francisco, Calif. — Ditzen Engineering and Sales, 5275 Claremont Ave., Oakland 9, Calif.
Oregon and Washington — Hydraulic Power Equipment Co., 2316 N.W. Savier Street, Portland, Ore.
Canada — D.M. Duncan Machinery Co., Ltd., 1958 Wyandotte St. East, Windsor, Ontario; 197 College St., Toronto, 2B

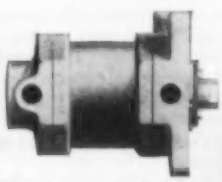


Air cylinders for 150 P.S.I.; seven mounting styles; nine bore diameters; strokes to 96"; cushioning.



Air valves for 150 P.S.I.; five kinds of operation; ¼" to 1" sizes.

Hydraulic valves for 1500 P.S.I., up to 3000 P.S.I.; 4 types of action; 5 piston designs; 6 operations; ¼" to 1½".



Hydraulic cylinders for 300, 1500 and 3000 P.S.I.; 7 mountings; 10 diameters; strokes to 96"; standard and 2:1 rod; cushioning.

Power units .4 G.P.M. to 40 G.P.M. at 1000 P.S.I. Double units 3 G.P.M. and .4 G.P.M. to 40 G.P.M. and 12 G.P.M. at 1000 P.S.I.

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Rivett Furnishes a Complete Power Package — Valves, Cylinders, Power Units Air and Hydraulic. All sizes and types.

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STRENGTH WITHOUT BULK

The exceptional tensile and torsional strength of Mac-it Screws makes it possible to use smaller, lower cost screws for all fastening jobs. Mac-it Special Alloy Steel used in all Mac-it Screws is held to rigid specifications, assuring uniform and dependable screw fasteners.

PRECISION FASTENERS

The precision manufacture and quality control used in making Mac-it Screws provide users with high dimensional accuracy and uniformity. All Mac-it Screws in both coarse and fine threads are held to a class-3 fit.

MAC-IT SCREW ENGINEERING

Mac-it maintains a fastener engineering service for the design, development and production of screws to suit all types of applications.

SPECIFY Mac-it FOR ALL THESE ADVANTAGES

ONE MAC-IT CALL GETS 'EM ALL!

SPECIAL SCREW PRODUCTS

Mac-it is geared for either large or small run production of screws with special design or strength characteristics.

HEAT-TREATING

Mac-it heat-treatment is more than a mere case hardening or surface processing. The high quality of Mac-it Special Alloy Steel adapts it to heat-treatment that penetrates throughout the structure of the screw so that the center possesses the same sturdy toughness possessed by the outside. Proved formulas govern this process.

Each type Mac-it Screw is heat-treated to possess maximum strength for the particular purpose for which it is to be used. No one heat-treatment is best for all purposes.

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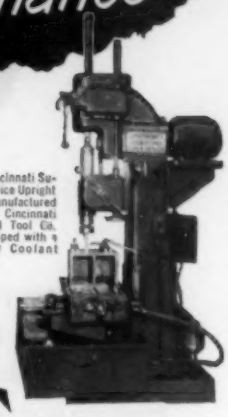
Contact any of the hundreds of Mac-it distributors from coast to coast for immediate service to supply your requirements for standard or special screws.

MAC-IT SCREW DEPARTMENT
STRONG, CARLISLE & HAMMOND COMPANY
1392 W. 3RD. STREET · CLEVELAND 13, OHIO
Manufactured by Mac-it Parts Co., Lancaster, Pa.

Cut Maintenance

TO A MINIMUM WITH A RUTHMAN GUSHER COOLANT PUMP



This Cincinnati Super Service Upright Drill manufactured by the Cincinnati Bickford Tool Co. is equipped with a Gusher Coolant Pump.

Check the features of every Ruthman Gusher Coolant Pump. They assure *you* of absolute minimum maintenance on your Gusher Pumps.

- Totally enclosed drip-proof motors.
- Pre-lubricated heavy-duty ball bearings.
- No packing or priming necessary.
- Electronically balanced rotating assembly to cut vibration to a minimum.
- No metal to metal contact within the pump.

Always specify Gusher Coolant Pumps.

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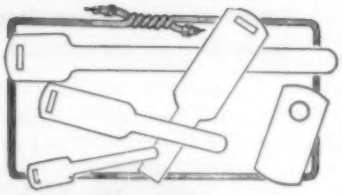

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- **For aircraft, radio, telephone, motor and generator manufacture, etc.**

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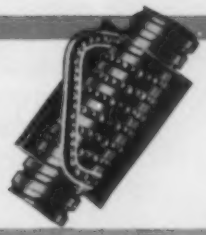
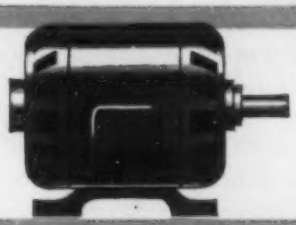
SEE PAGE 317

To MOVE with less EFFORT

BALL-SCREW ACTUATORS



REDUCE THIS



TO THIS

If you could take about 80% of the friction out of your moving device, you could vastly reduce the size of motor needed.

Our ball-screw actuator is a combination of the screw (for power) and balls (for friction-free movement).

Many U. S. airplanes have installations of our ball-screw actuators. They have been used to help replace big motors with small ones; to improve control of motion; to eliminate human work required to crank something.

Besides saving weight and reducing the cost of friction—besides providing absolutely smooth motion—besides minimizing need for lubrication—the Ball-Screw Actuator permits the precision control of metal to metal. You can stop on a split micron!

We have expanded our capacity so that we can engineer industrial applications now. Write for booklet describing actuators and their uses.

CLEVELAND PNEUMATIC
TOOL COMPANY

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BALL-SCREW ACTUATORS AIR-OIL SHOCK ABSORBERS

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CPT's shock absorber principle combines pneumatic and hydraulic cushioning. It can control minute vibrations or tons of impact. It is the shock absorber for the largest aircraft landing gear (CPT is world's biggest manufacturer of landing gears), but the principle can be adapted to finger-sized units. May we discuss with you how to ease the shock out of stopping or take the motion out of vibration?

WORLD'S LARGEST MANUFACTURER OF AIRCRAFT LANDING GEARS

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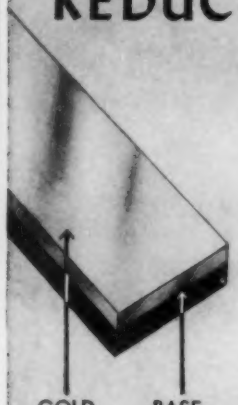

THE TREND toward high gold content (69% gold, 6% platinum, 25% silver, for example) rapidly leads to mounting costs for contact parts. These costs can be greatly reduced by using an *Improved* laminated metal. A precious metal alloy is solidly and permanently bonded to an inexpensive, non-ferrous base metal with the finished product just as effective as its more costly counterpart.

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At last! A *quantity* source of *precision* patterns on glass.

Gurley's expanded Industrial Division can now take on the *design* and *development* of your reticles and other precision patterns on glass—and *manufacture* them, too, to the closest tolerances, in quantities of one or one thousand.

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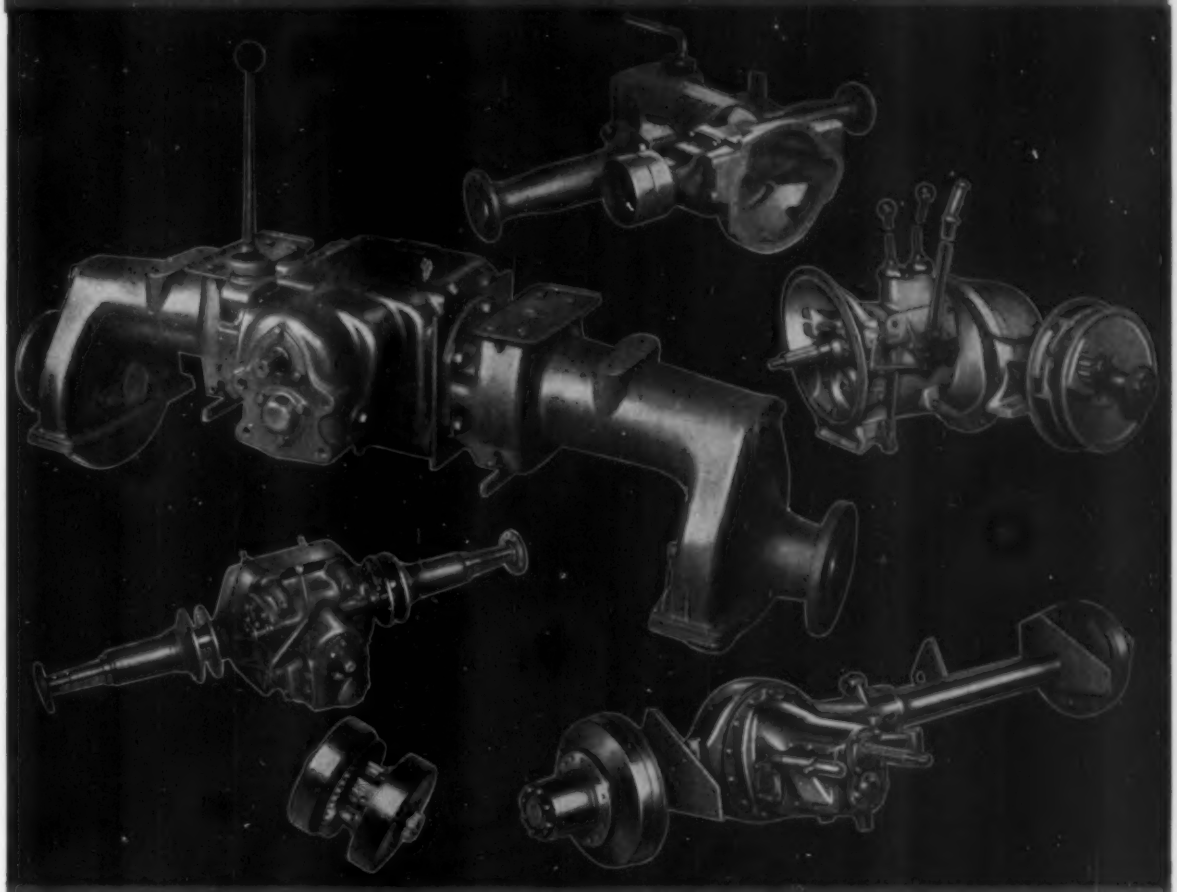
A CLINCHING CASE OF "CLASS"



—these CLARK axle-transmission Drive Units

In search of leadership? . . . There's a way to put into your product—any agricultural, industrial, heavy duty highway or off-highway vehicle—that ingredient of Class that achieves distinction: *Equip it with a Clark Drive Unit* . . . These units are different, custom-designed for specific jobs. That's how yours will be created—your engineers and Clark engineers working together, tapping a pool of priceless experience, to create a really dependable driving unit . . . It has been tried by leading builders—and it works.

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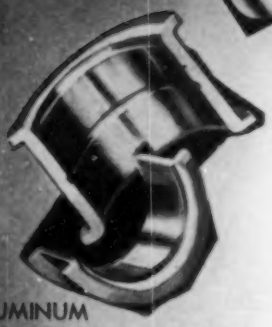
PRODUCTS OF CLARK . . . TRANSMISSIONS • AXLE HOUSINGS • TRACTOR UNITS • FORK TRUCKS and TOWING TRACTORS • ROSS CARRIERS • POWRWORKER HAND TRUCKS • POWER SHOVELS • ELECTRIC STEEL CASTINGS • GEARS and FORGINGS • FRONT and REAR AXLES for TRUCKS and BUSES

JOHNSON B BEARINGS
Sleeve-Type



for Every Shaft

WHEREVER a shaft turns there is probably an application for a Johnson Sleeve Bearing. The range of types and sizes is the widest on the market. Johnson Bearings are used in industrial equipment, automotive, aircraft and transportation equipment, electrical equipment, farm machinery, earth-moving equipment . . . in fact, wherever a shaft turns. They are available in standard stock bearings or made-to-order for specific applications. Johnson engineers will gladly consult with you on your bearing problems. Write today.

JOHNSON BRONZE COMPANY, 508 South Mill St., New Castle, Pa.

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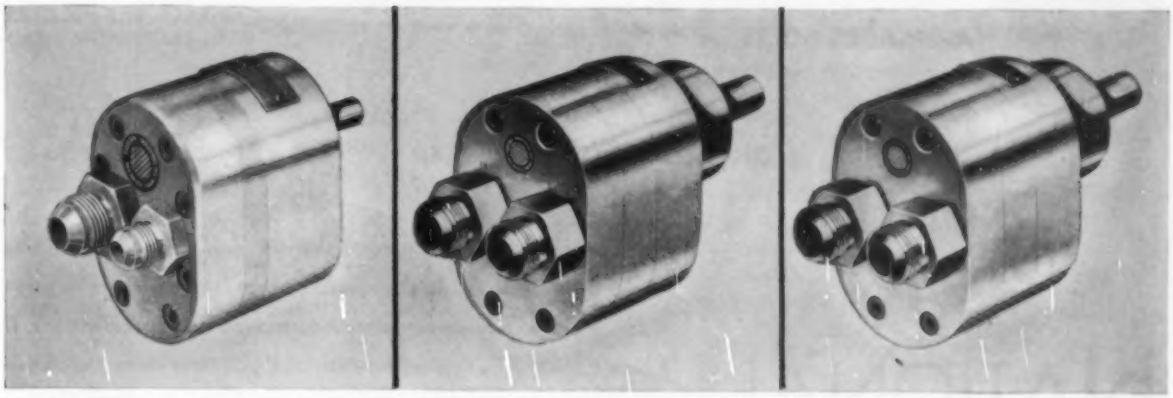
HYDRAULIC PUMPS FLUID MOTORS

Design engineers have confidence when they specify dependable Eastern Hydraulic Pumps and Fluid Motors. Exclusive Eastern features create an economical, reliable, and compact unit for the heart of your hydraulic mechanism.

Lightweight construction of aluminum alloy housing, nitralloy gears and shaft, and close tolerances assure longer service, higher volumetric efficiency, and more dependable operation. Various types of mountings are available for space saving installation.

In many cases by specifying an Eastern unit you realize dollar savings as well as great savings in size. They cut operating costs by keeping space requirements and weight to a minimum.



100 Series — Heavy duty gear pump. Delivery from .1 to 5 gpm and working pressures up to 1,500

700 Series — High pressure gear pump. Delivery from .6 to 9.6 gpm and pressures up to 1,500 psi.

2700 Series — Gear type fluid motor. Torque output — 0 to 15 ft. pounds.

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OIL AND WATER SEALERS — OIL & WATER SEALING COMPOUNDS

Here is the Table of Contents that you will find on the Preface Page of our new 160 page catalog that is about to go to press . . . Besides having complete information and specifications, it contains much engineering data . . . If you have immediate need for such information we have a limited quantity of the current edition that can be supplied upon request without delay.

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How Cindus X-CREPE® gives Longer Life

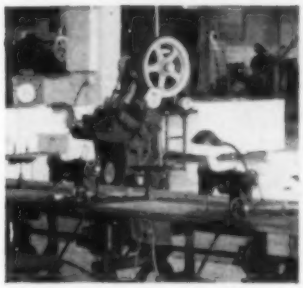
to death-dealing U.S. Fly Swatters

X-Crepe makes clean, firm edge-binding . . .
Replaces expensive felt, leatherette.

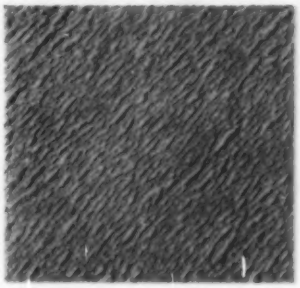
Long life, ability to withstand hard wallops from day to day—are prime requirements in top grade, dependable fly swatters. Whether swatter blade is wire-cloth, fiber or cellophane, *tough, durable edge-binding* is the key to more trouble-free swat mileage.

United States Mfg. Corp., Decatur, Ill., world's largest fly swatter manufacturer, used to bind with expensive felt and leatherette. Disturbing field reports indicated this binding frayed, deteriorated—too soon. Blades would kink. Even experienced wielders got too many "misses" and "probables."

Then E. W. Twitchell Inc., Phila., Pa., binding experts, recommended sturdy, economical X-CREPE for the job. X-CREPE won't crack, is pliable, formable, creasable, sewable, easy to work with—perfect for dependable edge-binding.



In the sewing room, X-CREPE is easier to work with than felt or leatherette. U. S. feeds bright-colored X-CREPE from ⅝" wide rolls into binder. X-CREPE creases readily, won't "drag" through binder, doesn't break thread or slow production. Material goes smoothly onto swatter blade, gets high-speed zig-zag stitch on electric Singer Sewing Machines. Out comes another strong, attractive U.S. Swatter.



X-CREPE is pliable, stretchable, formable. It can be impregnated, coated, laminated—or combined with cloth and fibers, films and foils to extend the use of such materials far beyond their usual limits. It can be used like cloth, instead of rubber, in place of cork, and for jobs where no other material will do. Available in a wide range of basis weights—sheets, rolls, die-cut shapes, bags and liners.

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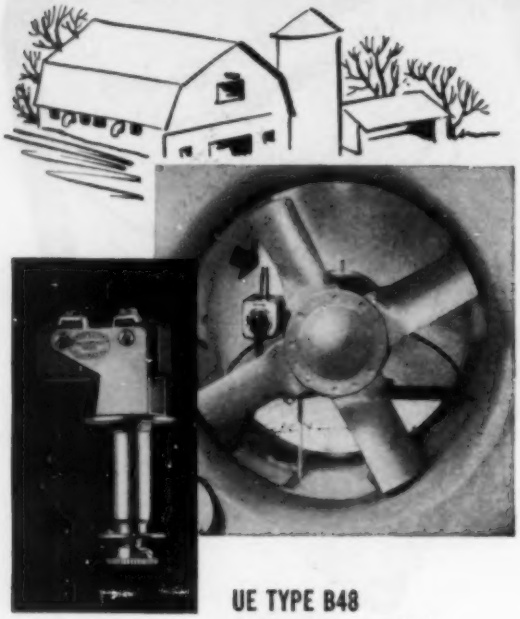

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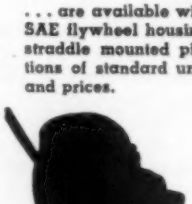

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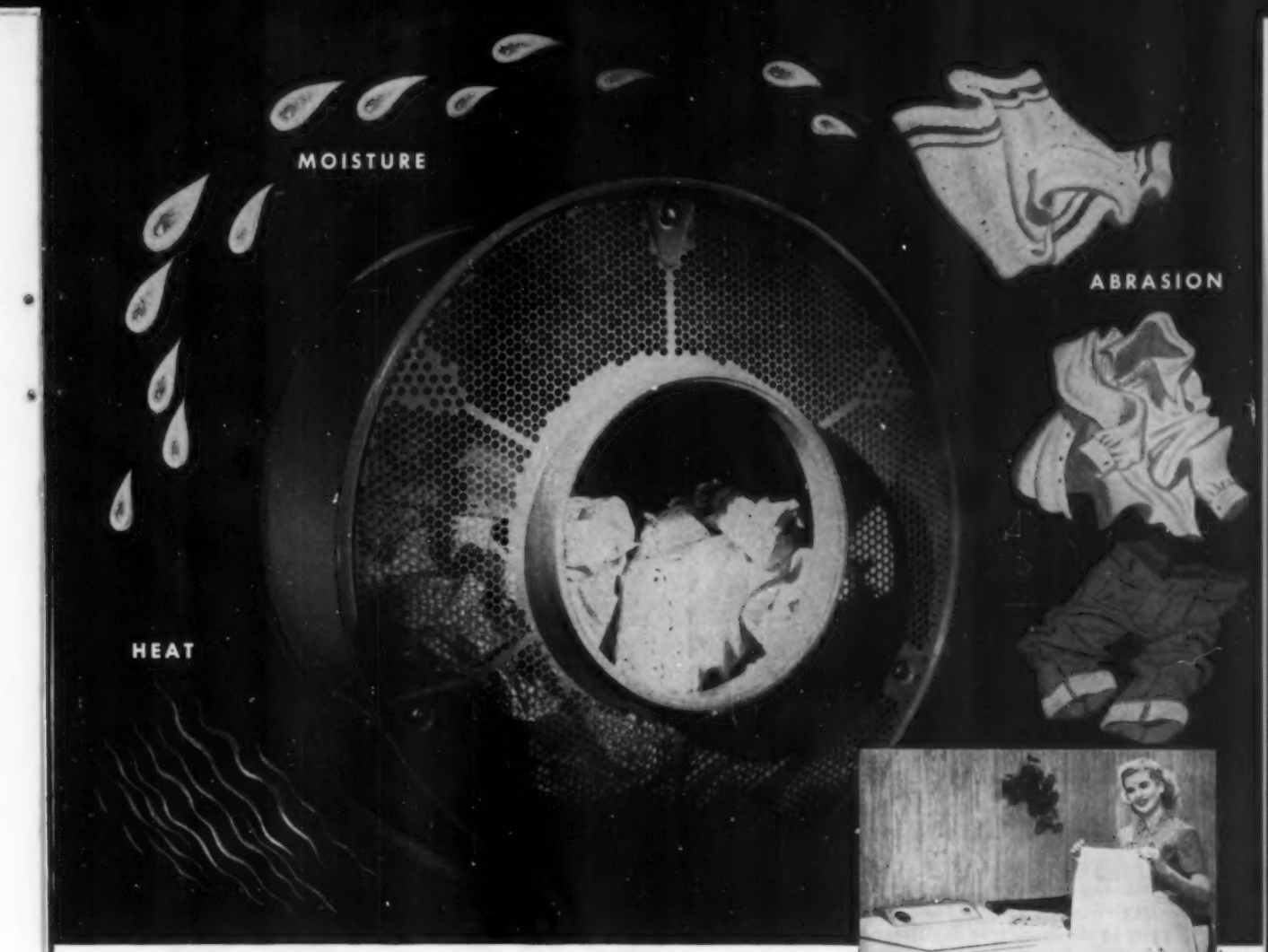

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The finish on the drum of the new Caloric gas dryer must withstand extreme moisture, heat and severe abrasion action. To meet these attacks, and to solve problems in the finishing of their new unit, Caloric Stove Corporation, Topton, Pennsylvania, called on Glidden Technical Service.

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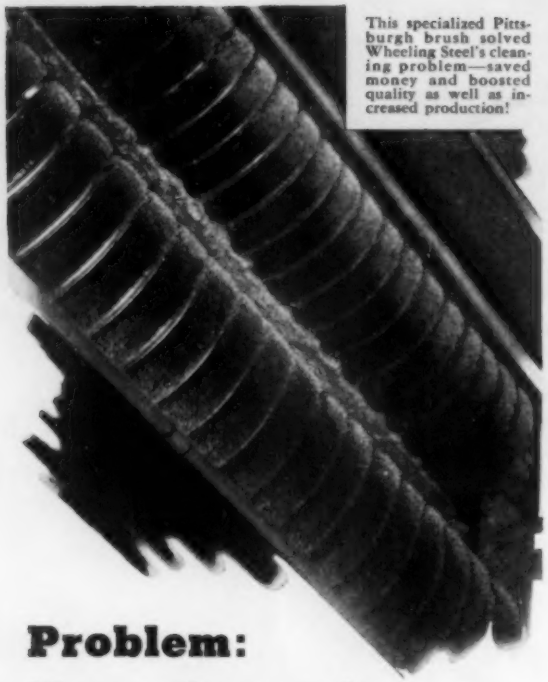

This specialized Pittsburgh brush solved Wheeling Steel's cleaning problem—saved money and boosted quality as well as increased production!

Problem:

How to be tough and soft at the same time!

That was the problem presented to the Pittsburgh Plate Glass Company by the Steelcrete Division of Wheeling Steel, Beech Bottom, W. Va.—and it required a specialized Pittsburgh brush to solve it!

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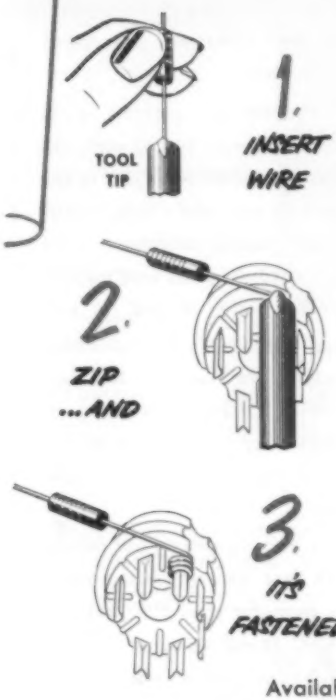

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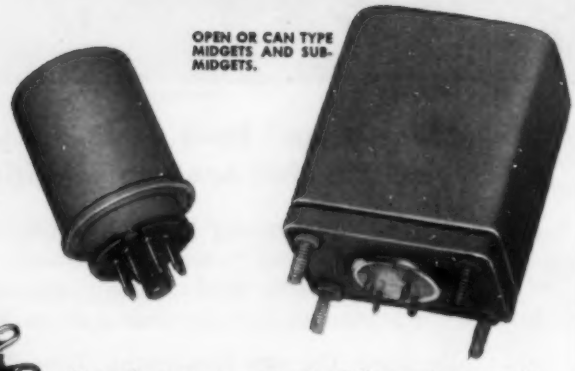

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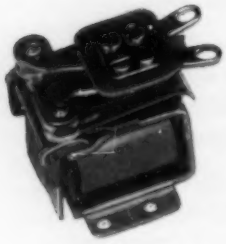

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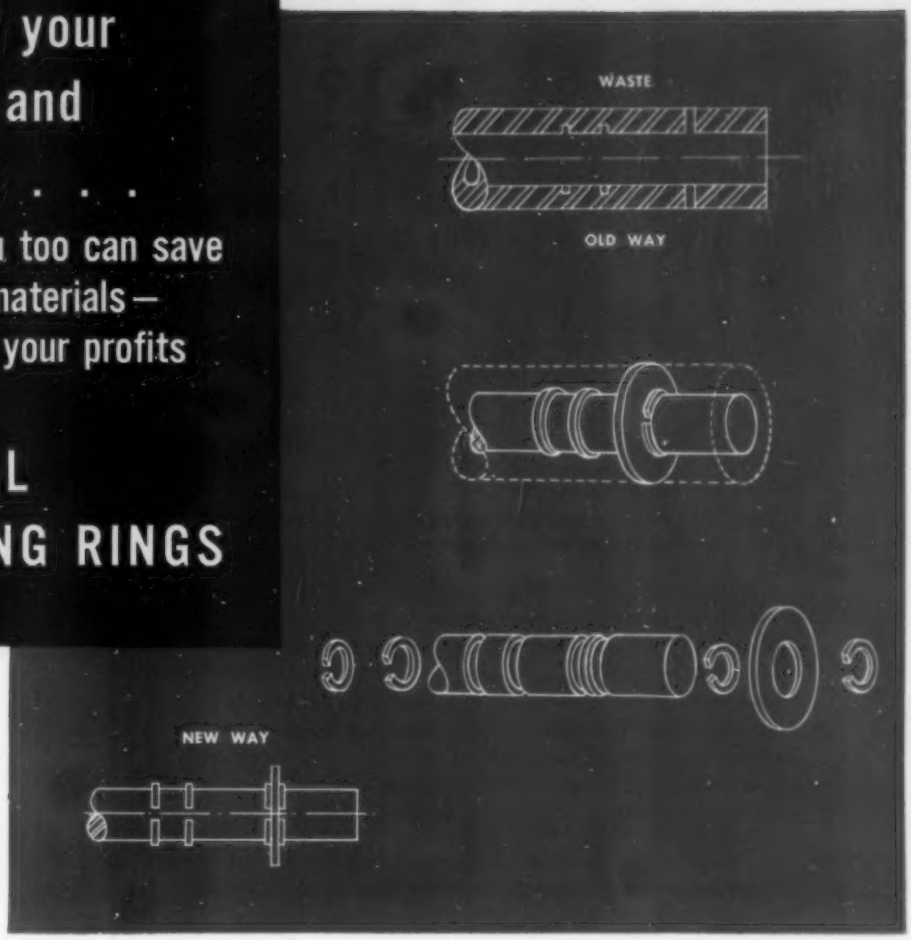

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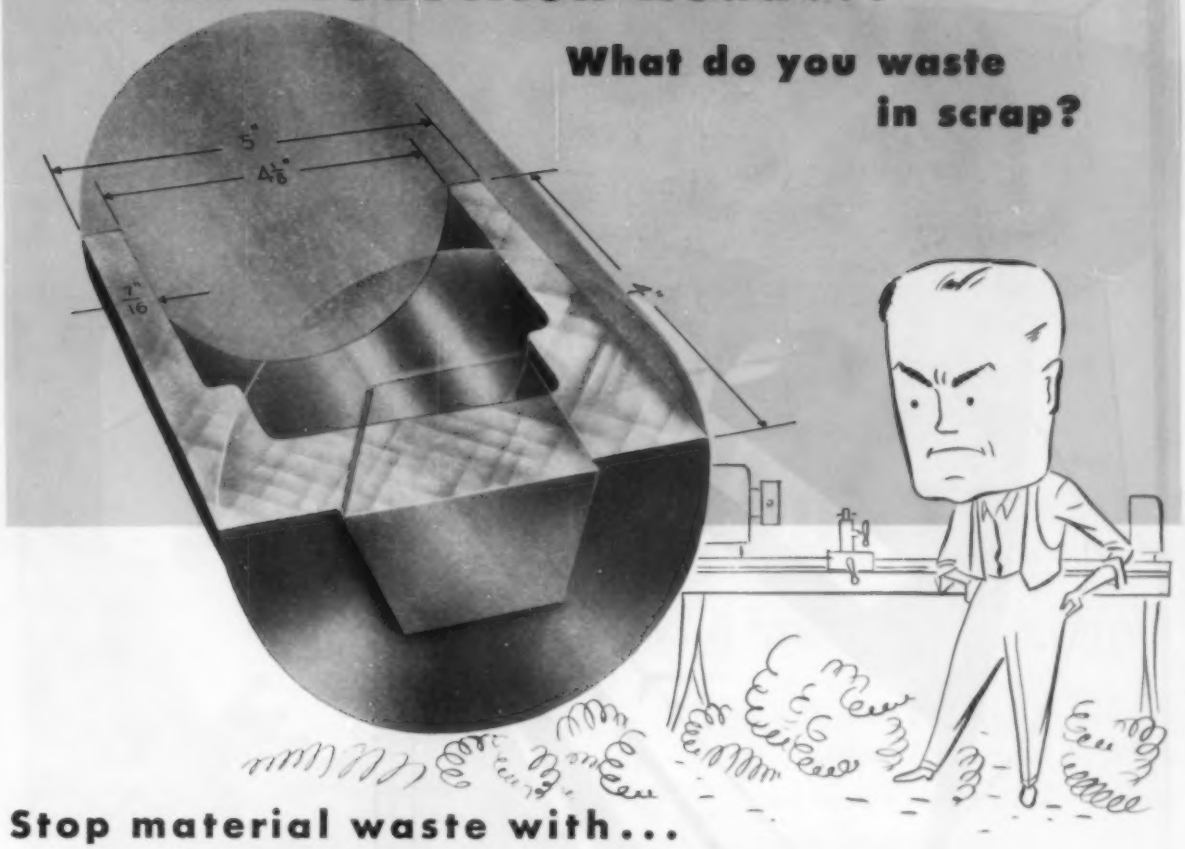

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Think of the metal waste if the cylinder cap shown above were machined! The turnings would represent dead loss—expensive material and machining time.

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Hunter Douglas has produced millions of high strength aluminum alloy impact forgings at great savings in time, cost, and material. If you are designing or producing a part calling for close tolerances and high strength, in quantities of from one thousand to one million per month, find out how Hunter Douglas Impact Forging can improve your production picture.

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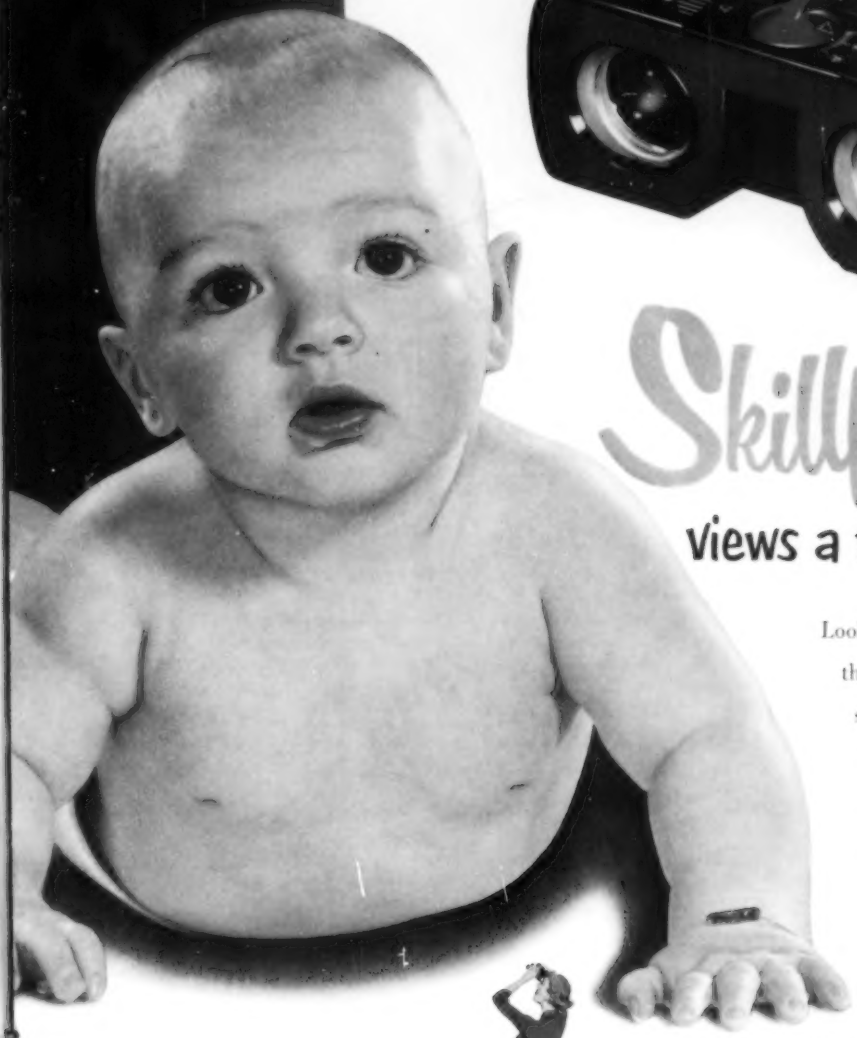

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Look at this viewer and you will see much more than a skillfully molded housing for a superb stereo optics system. You will see another reason why we are especially well equipped to mold your camera and photographic products—or any thermoplastic products for that matter. We can tell you a long story of product molding and engineering accomplishments. There's plenty of variety in this story for we have molded low cost mass production items, as well as outstanding sellers in the luxury price class.

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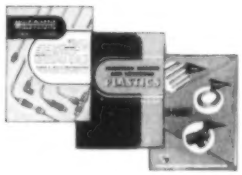

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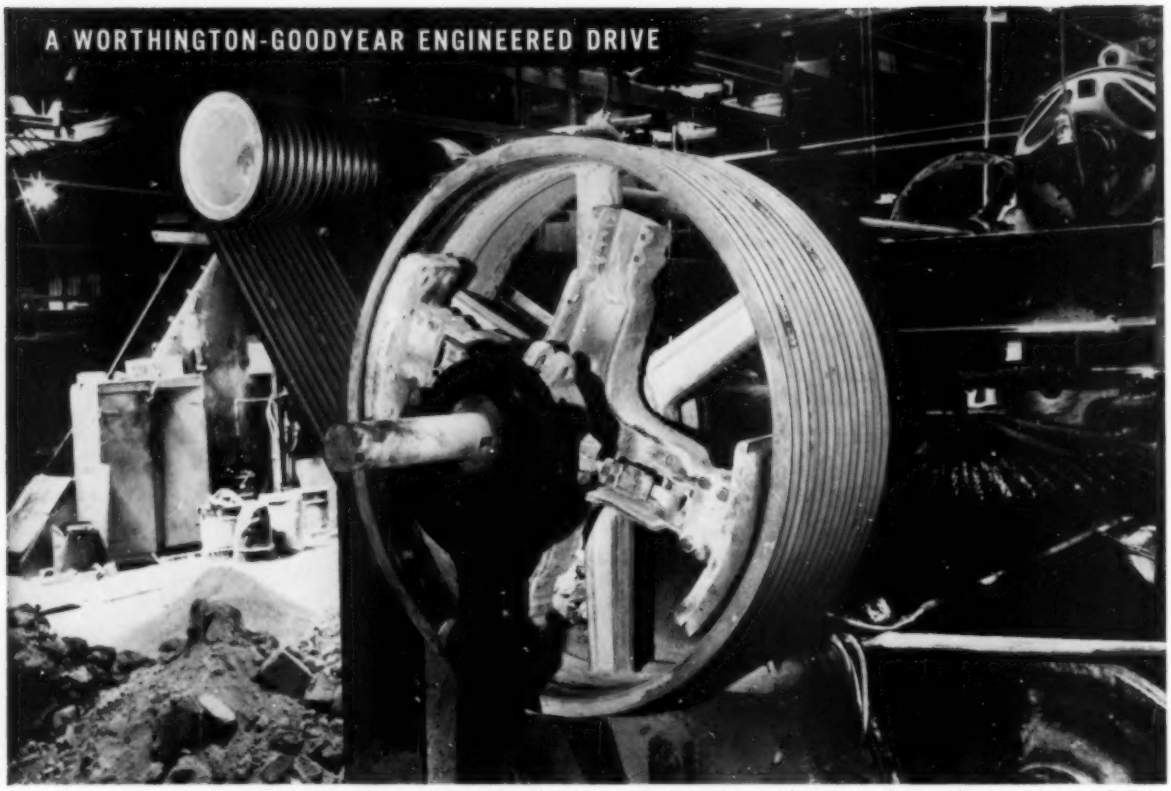
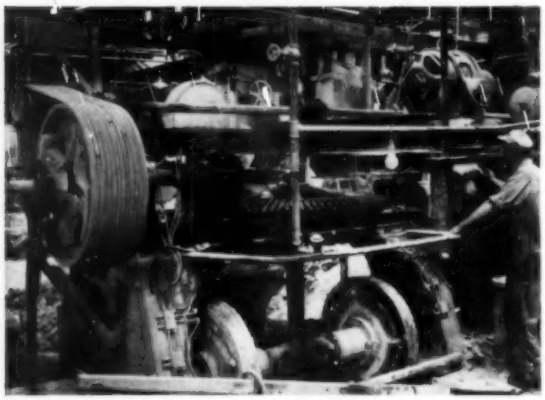


WORTHINGTON MULTI-V-DRIVE takes heavy shock loads on this wet-pan that crushes huge lumps of clay.

Belts hold as machine crushes 120-lb lumps



SMOOTH, NON-SLIP DRIVE for this wet-pan is provided by Worthington QD sheaves and Goodyear V-belts.

Worthington Multi-V-Drive solves critical drive problem

Driving a machine that crushes, mixes and tempers crude clay is a real workout for any mechanical power transmission setup—especially with lumps weighing as much as 120 pounds.

After two years of this heavy-duty operation, not one belt has been replaced on this wet-pan. And there's no noise, slippage of belts on sheaves, and no resulting power loss. Because of this fine record, Worthington Multi-V-Drives, with QD* sheaves and Worthington-Goodyear V-belts, will be installed on other wet-pan pulverizers.

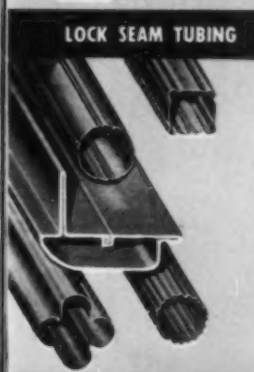
Find out how this Worthington-Goodyear drive team can pay off for you, too. Write us. Worthington Corporation, Section MV.4.5, Oil City, Pa. *Reg.U.S.Pat.Off.

MV.4.5

WORTHINGTON

SPECIFY THESE WORTHINGTON STANDARD PRODUCTS ON *YOUR* EQUIPMENT

Compressors • Pumps • Multi-V-Drives • Variable Speed Drives



Van Huffel cold formed metal shapes and tubing simplify design and cut production costs for the makers of

farm equipment

No matter what you make that farmers use, chances are Van Huffel Cold Formed Metal Shapes and Tubing can help you make it faster, cheaper and better.

Faster **because cold formed parts require very little or no machining; parts come to you shaped, cut, punched, or bent to your specifications.**

Cheaper **because of the high strength-to-weight ratio you can, in many cases, use lighter gauges, or smaller sizes in place of solid metals. Parts are uniform in thickness, free from scale, and ready to paint.**

Better **because of the wider latitude in choice of materials, design possibilities and fabrication methods. Shapes and tubing can be produced in Cold Rolled, Hot Rolled and High Tensile Steels. Van Huffel cold forms strip metals 1/2" to 33" wide; regular and irregular shapes in .018 to .312 gauge; tubing from 3/16" to 6" in diameter in any lengths.**

As competition brings demands for simplifying parts and lowering costs, we invite you to consult us on the possibility of doing the job better and more economically with Van Huffel metal shapes and tubing.

Van Huffel

TUBE CORPORATION · WARREN, OHIO

Where ideas take shape for makers of farm equipment

for durable and dependable

Stupakoff

glass-to-metal seals

A complete range of sizes and designs of terminals, lead-ins and stand-offs for hermetic sealing is offered by Stupakoff. Made with Kovar metal, the ideal alloy for sealing to hard glass, Stupakoff Seals are durable and dependable. These are not mechanical compression seals, but are permanently fused by chemical interaction. They may be installed by conventional assembly techniques.

Write for a copy of the new Stupakoff Catalog 453, giving details of over a thousand sizes and styles of Stupakoff Seals.

STUPAKOFF CERAMIC & MANUFACTURING COMPANY

LATROBE, PENNSYLVANIA

Molder: General American Transportation Corp., Chicago, Ill.

KOPPERS POLYSTYRENES

Type 3	General Purpose Polystyrene
Type 7	Improved Heat Distortion Temperature
Type 8	Highest Heat Distortion Temperature
MC-185	"High Impact," Lowest Water Absorption Rate
MC-301	"High Impact" Improved Heat Distortion
MC-305	"High Impact," Easy Flow
MC-309	"High Impact," Highest Heat Distortion Temperature
MC-401	"Medium Impact," Improved Heat Distortion Temperature
MC-405	"Medium Impact," Easy Flow
MC-409	"Medium Impact," Highest Heat Distortion Temperature

• Westinghouse Electric wanted another liner for refrigerator doors—one that would be easy to clean, odorless, shock-resistant, and yet low in cost.

The molder, General American, suggested use of a liner made from a special, high-impact plastic. Koppers Modified Polystyrene MC-305 met the requirements, and is now used in several Westinghouse refrigerator models.

Koppers Polystyrenes, both regular and modified, have helped many manufacturers improve their products, and/or cut production costs. These plastics flow easily during molding, thereby reducing the molding cycle and increasing production. Our technical staff will be glad to assist you in selecting the specific Koppers Polystyrene that best fits your needs. Call or write your nearest Koppers office.

Koppers Plastics Make Many Products Better and Many Better Products Possible.

KOPPERS

Koppers Plastics

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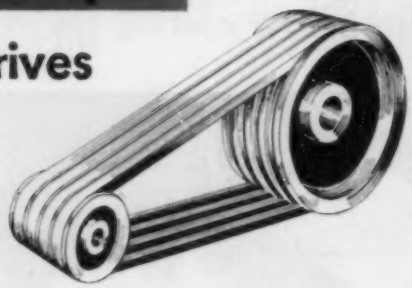
whether
it's multiple
v-drives



or fhp v-drives

Maurey will meet your V-drive needs

The chances are better than even that your V-Drive requirements can be met in full from the complete stocks of Cast Iron and Pressed Steel V-Pulleys, Sheaves, V-Belts and drive parts in the complete Maurey Multiple and FHP V-Drive lines. If you require special sizes or designs of V-pulleys, sheaves or parts, Maurey is staffed and equipped to meet your needs and stay within your budget.

On any V-Drive problem the help of widely experienced Maurey engineers is available to you *without obligation*. A more efficient drive and lowered cost often result from a Maurey engineering analysis.

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The Complete V-Drive Line . . . Serving Industry since 1917

SAUEREISEN NO. 78

A READY-MIXED REFRACTORY CEMENT FOR ELECTRICAL USE!

Sauereisen No. 78, an excellent insulator of electricity at high temperatures, is ideal for coating resistors, electric heating elements, electric furnaces and embedding resistance wires. Radiates heat, resists oil, solvents, most acids—hardens into a porcelain-like body—will not injure the finest resistance wire!

Sauereisen No. 78 cements everything from cigar lighters to electric furnaces. Replaces insulating varnish, enamel, mica, asbestos.

SPECIAL TRIAL ORDER 1 GAL. $4.95

FREE "CATALOG OF USES" WITH TRIAL ORDER!
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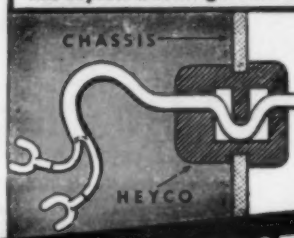
SAUEREISEN CEMENTS COMPANY
PITTSBURGH 15, PENNSYLVANIA

Facts you should know about HEYCO STRAIN RELIEFS!
the Nylon Bushings that Anchor cord to housing



1. Absorb cord pull, push and torque
2. Insulate wire from housing

CUT PRODUCTION COSTS
IMPROVE PRODUCT QUALITY
APPROVED SA UL

SAMPLES? Send wire size and chassis information—
Try HEYCOS at no cost to you—today!
MADE IN ALL SIZES FOR CLOCK WIRE TO S-10/3 CABLE

HEYMAN MANUFACTURING COMPANY
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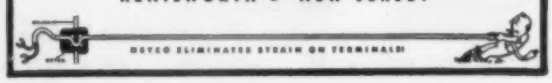
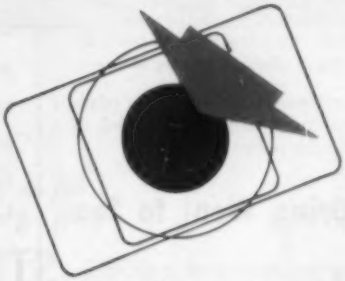


O-M CYLINDERS

air • hydraulic

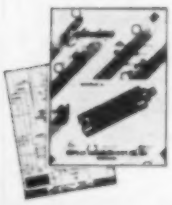
fit where others won't!



O-M Cylinders require up to ⅓ LESS INSTALLATION SPACE than conventional cylinders of the same bore, because O-M's *Special Interlocking Mechanism* eliminates projecting tie rods and bulky end caps. In addition, the "O. D." of O-M Cylinders can be easily and accurately machined for cartridge mounting within your equipment.

O-M Special Interlocking Mechanism also assures perfect alignment giving O-M the lowest coefficient of friction of any cylinder. Thus, O-M Cylinders are smoother operating at low or high speeds regardless of length of stroke. Easily removed, inspected, repaired, replaced. Completely interchangeable parts.

Available in a full range of sizes (1½" to 8" bores) with standard, 2 to 1 or oversize rods. *14-day delivery on most sizes.*



Write today for FREE catalog and complete set of ½- and ¼-scale templates showing all cylinders and mounting brackets.

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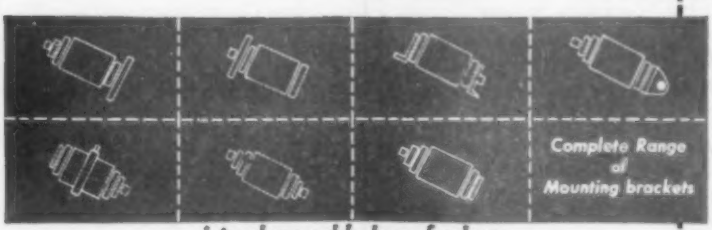

interchangeable bore for bore

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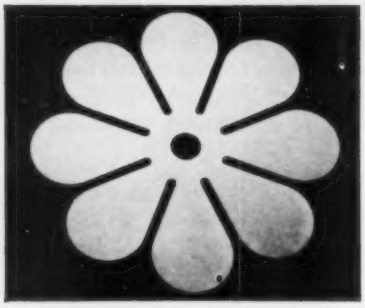
Smooth-Sailing Evinrudes Have Smooth Breathing

From the clear, throaty song of a distance-covering cruise to the quiet murmur of a dead-slow troll, Evinrude's outboard motors are famous for their dependable power performance. Their half-century of leadership is well deserved, for Evinrude's design and production methods always aim toward a better product. The need for smoother and more dependable carburetion added I-S to the Evinrude crew.

Evinrude's engineering staff was confronted with a triple-factor spring problem:

1. GRAIN DIRECTION — 8 springs in one, each leaf 45° from adjacent leaves.
2. FLATNESS—Each leaf must be perfectly flat to insure absolute closing of valve.
3. HIGH ENDURANCE LIFE—Die-cut edges have tiny irregularities which lead to failure under severe service.

How an I-S Beryllium Copper Spring Went to Sea



1. THE CRITICAL EFFECTS of grain direction were completely negated by Micro-Processing.
2. SPECIALLY DESIGNED JIGS used in the heat-treating operation resulted in overall flatness to a tolerance of ±.002 per inch.
3. I-S EXCLUSIVE ENDURANCE FINISH removed edge and surface imperfections, leaving the spring in ideal condition for repeated stresses of high magnitude.

This Evinrude case report is typical of the improved product performance available through I-S experience and techniques in Beryllium Copper spring-making. If you are seeking a source for "problem springs" . . . from prototype to mass production . . . we invite you to call upon us.

It costs nothing to compare . . . it may cost considerable *not to!*

Instrument Specialties Co. Inc.
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An independent client report summarizing the results of I-S techniques for increasing the endurance limit by 39%—from 34,000 psi to 48,500 psi—at moderately high stress —50 million-plus cycles of reversed stress.

JUST ONE of many valuable features in the 1955 HANDBOOK of Product Design will be an authoritative report on

CELLULAR RUBBER AS AN ENGINEERING MATERIAL

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Work has been going forward on your 1955 HANDBOOK since last November. It will be ready in October, and will come to you as part of your regular subscription to *Product Engineering*. And, as before, the HANDBOOK will have ten complete sections covering new and significant developments in every field of design-engineering. The 1955 edition will *supplement* the 1953 and 1954 HANDBOOKS which you are using now. In less than two years, the Annual HANDBOOK of Product Design has become the most eagerly awaited yearly publishing event in the design field!

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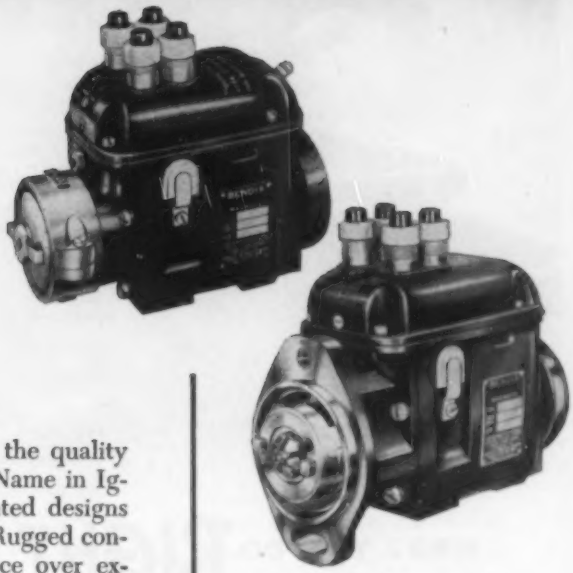
specify Bendix PA and PAF series magnetos



Here in the PA and PAF series magnetos, built to the quality standard that has made Bendix—The Most Trusted Name in Ignition—are a wide variety of base and flange mounted designs for agricultural, petroleum, marine or industrial use. Rugged construction throughout assures trouble-free performance over extended periods of time.

Detailed information available on request.

OUTSTANDING FEATURES: ***Aircraft Quality • Full Ball Bearing Weatherproof • Metal Distributor Cover • Shielded High Tension Outlets • Pivotless Aircraft-Type Breaker • Adjustable Lags and Lug Position • Unexcelled For High Speeds • Lower Maintenance Cost • These Features Assure Long Trouble-Free Operation.***

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WHAT YOU DO RIGHT NOW IS MIGHTY IMPORTANT

That moment when he hits . . . if you don't set the hook hard and firm, you'll never see him in the boat. And *this* moment in business . . . now's the time to give yourself the competitive edge that means so much when the going is tough. ● Allegheny Metal can reduce costs, add strength, increase service life, improve appearance, cut weight, overcome rust. How many of these properties of stainless steel can you use to advantage, and how can we help you to do so? ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pennsylvania.***

You can make it **BETTER** with

Allegheny Metal

AL® TIME-TESTED STAINLESS STEEL

Warehouse stocks carried by all Ryerson Steel plants

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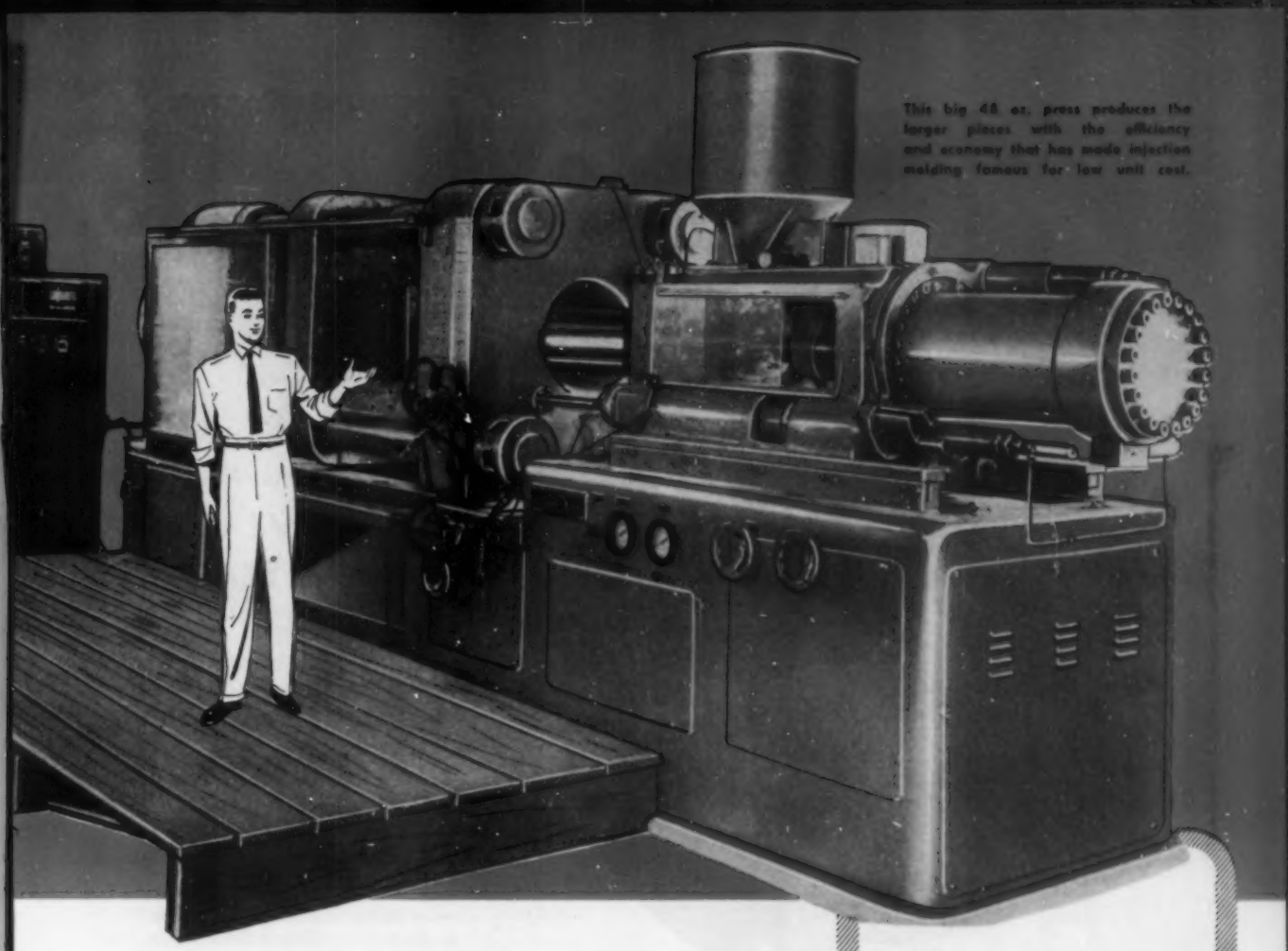


This big 48 oz. press produces the larger pieces with the efficiency and economy that has made injection molding famous for low unit cost.

a "press-fit" at Aico

cuts cost of injection molded plastics

Unused press capacity means a high unit cost. Aico avoids this waste to cut costs on all injection molding. Aico has a press to fit each job. A big one for a big job . . . a little one for a little job . . . Aico has at least one press that's just right to meet your design and delivery requirements when operated at its most efficient production rate, full capacity.

A fully equipped injection molding department, with presses from 2 to 48 oz. capacity, offers a plus value you can't afford to miss. It provides you with a single source for a wide variety of injection molded parts. It offers the convenience and economy of working with a single supplier.

No other plastic molder has a more modern plant . . . a broader range of experience . . . to place at your disposal. Talk to Aico about your plastic problem. We'd appreciate the chance to be of service. There's no obligation . . . drop us a line today. Let Aico take over for you.

AMERICAN INSULATOR CORPORATION
NEW FREEDOM, PENNSYLVANIA

ALCO's

Complete Plastic Molding, Service Includes:

ENGINEERING COUNSEL on proper molding methods and materials.

MOLD BUILDING to avoid division of responsibility.

INJECTION MOLDING for high rate of production . . . low unit cost.

COMPRESSION MOLDING of large parts with heavy cross sections.

COLD MOLDING of electrical parts requiring high heat resistance.

MOLDING OF REINFORCED PLASTICS . . . a relatively new low pressure development especially suitable for short runs of large light weight pieces.

MANY THINGS ARE BETTER BECAUSE OF

Aico PRECISION MOLDED plastics

in Perkins custom-made Gears

We have manufactured precision gears to customers' specifications for over thirty years. This collective experience enables us to approach any gear engineering problem with a vast amount of "hindsight." For no matter how exacting your particular requirements may be, they cannot exceed those of many of our regular customers. The return of a buyer's market places a premium on quality. And if — in the product you manufacture, quality is synonymous with trouble-free power transmission — our gear engineering service will be of great value to you right now. Ask us for suggestions, ideas and cost estimates today.

PERKINS MAKES: helical gears, bevel gears, sprockets, ratchets, worm gears, spiral gears, spur gears with shaved or ground teeth, ground thread worms.

NOTE 1: A new product is the Perkins Precision Spring Coiler. This coiler (patent applied for) turns out precision springs – any type, shape, size, from wire sizes .005 to .125.

2: Another new product – the Perkins "Bendit 15" – a patented metal forming machine bends and shapes sheets, rods, strips tubing into innumerable complex as well as simple forms that would be difficult or impossible to make by other means. Eliminates need for expensive tools or specialized skills. Ht. 47", net wt. 200 lbs. Write today for descriptive catalogs, prices etc.

PERKINS Machine & Gear Co.
WEST SPRINGFIELD, MASSACHUSETTS

33 years ago they told me:

"YOU HAVE LESS THAN A YEAR TO LIVE!"

"MUST HAVE BEEN back in 1919 or '20. Hopeless case of diabetes. No known cure . . .

"BUT HERE I AM. They found a treatment—insulin—in time. Today, *nobody* has to die of diabetes.

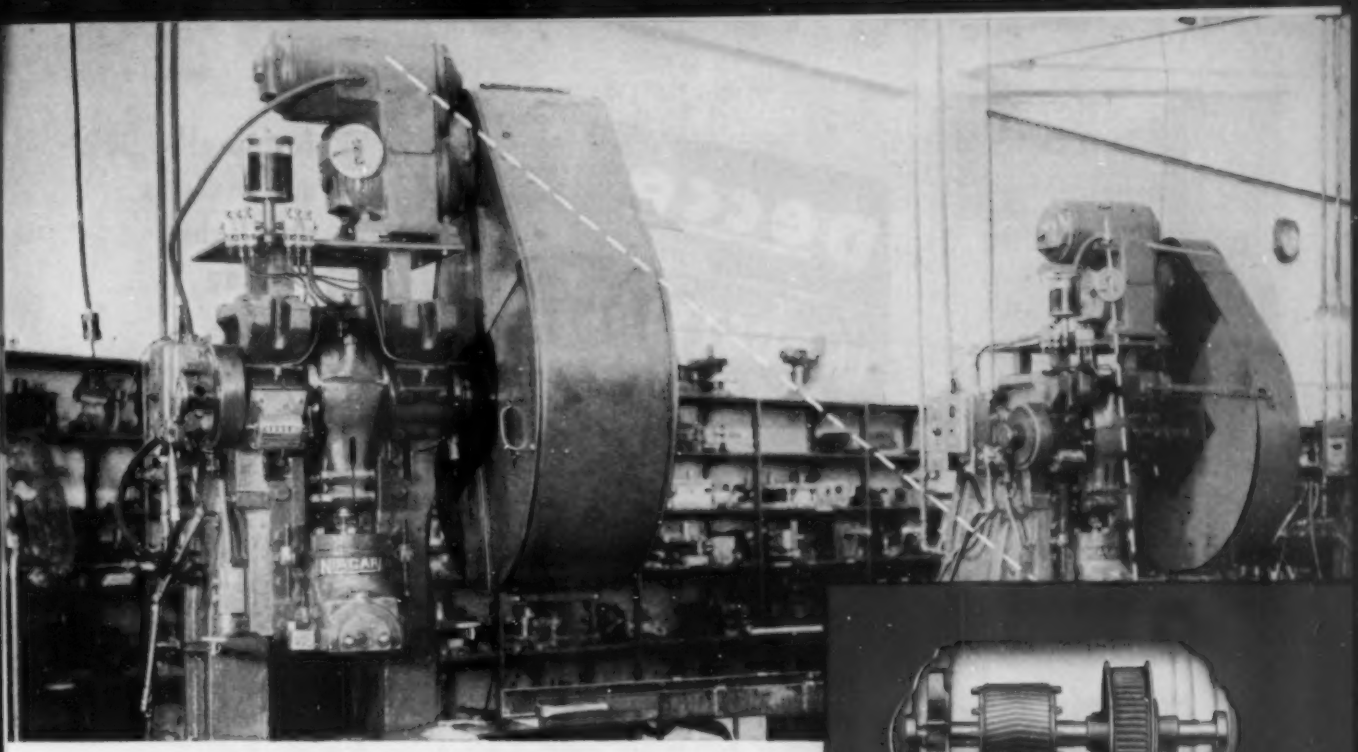
"CANCER, I know, is a tougher problem. But the laboratories can lick that one, too—with our support. Already, they're curing people who would have been done for a few years ago. Last year—thanks to $5,000,000 allocated by the American Cancer Society from our contributions—they found out a lot more . . . though there's still a long way to go.

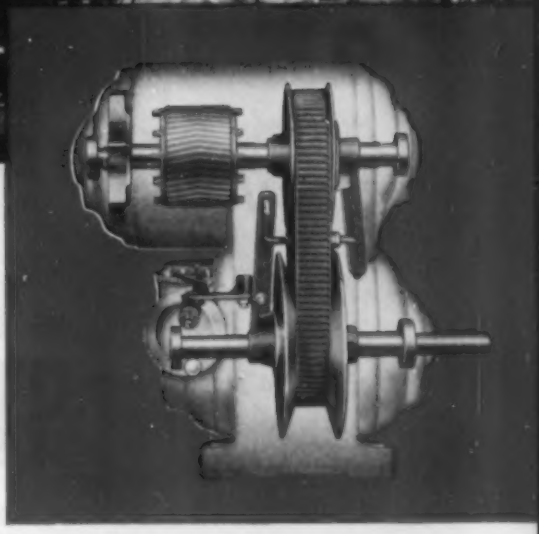
"THEY NEED MONEY, though. $5,000,000 is still less than 4 cents per American *per year*. Not enough. Not enough to find the answer *fast* enough—230,000 Americans are going to die of cancer *this year*, they say.

"I'M NOT RICH, but I gave 'em $50 last year—hope to do better this time. After all, where would *I* be if the laboratories working on diabetes, that time, hadn't been given enough support—?"

Cancer
MAN'S CRUELEST ENEMY
Strike back—Give

AMERICAN CANCER SOCIETY
GENTLEMEN:
☐ Please send me free information on cancer.
☐ Enclosed is my contribution of $..... to the cancer crusade.
Name.....
Address.....
City.....State.....
Simply address the envelope: CANCER c/o Postmaster, Name of Your Town





PUNCH PRESS OUTPUT UP 30% WITH SPEED-TROLS AT SQUARE D CO.

Replacement of single speed motors with Speed-Trol variable speed drives on punch presses at the Los Angeles factory of Square D Company resulted in the following advantages, reports L. G. Maechtlen, Vice President: Production increased 30%...spoilage or rejects reduced 10%...presses adapted to 40% more jobs...100% synchronization of punch press speed and operator's ability...employee morale greatly improved.

Speed-Trol...Variable Speed at its Best

OUTSTANDING FEATURES:

A Single, Compact Power Unit containing motor, variable speed transmission, with or without integral speed reducer—**Effective Cooling Systems** with direct-through ventilation, dual or internal cooling—**Positive Pulley Adjustment** for infinite speed variation, accurate speed selection and regulation—**Fingertip Control of Speed** with standard or remote controls—**Specially Designed V-Belt** for heavy duty, long life—**Protected Designs,** drip-proof, splash-proof, totally enclosed—**Rugged Construction** for continuous duty, permanent bearing alignment—**Streamlined** for easy cleaning, better appearance—**Interchangeable Mounting Dimensions** between constant and variable speed drives—**Versatile Mounting** for any position—**Smooth, Quiet Operation** through dynamic balancing; Herringbone Rotor; pre-lubricated, double shielded ball bearings—**Low Installation Cost** due to compact design, versatile mounting, interchangeable mounting dimensions.

20-PAGE ILLUSTRATED CATALOG ...Sterling Speed-Trol, Slo-Speed, Klosd and Klosd-Tite Electric Power Drives. Write for catalog No. D-431.

There is a Sterling Electric Power Drive to Meet Virtually Every Requirement

Sterling Slo-Speed Electric Power Drives—for geared low speed at its best
Sterling Klosd and Klosd-Tite Motors—for constant normal speed at its best

STERLING ELECTRIC MOTORS

Plants: New York City 51 • Chicago 35 • Los Angeles 22 • Hamilton, Canada • Santiago, Chile
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Metal-Cal®

-the mark of quality on America's fine products

Labels—nameplates—trademarks—alert manufacturers find more uses every day for Metal-Cal's unusual qualities. Metal-Cal is .003-inch aluminum foil, with the design made of colors absorbed and sealed into an *anodized* surface. The result is a clear, sharp design in brilliant, metallic color . . . amazingly resistant to abrasion, moisture, heat and cold. Metal-Cal's pressure-sensitive back bonds to any smooth, cohesive surface. No need for screws or rivets.

Metal-Cal obsoletes traditional metal nameplates and decals. As industry learns its advantages . . . in savings on material and labor and in lasting good looks . . . Metal-Cal wins new users.

Your product deserves this mark of quality—a Metal-Cal trademark or label.

Write for Write for the BASIC DATA FILE and samples of Metal-Cal for your own test.

Metal-Cal, Dept. H-1
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415 E. Beach Ave.
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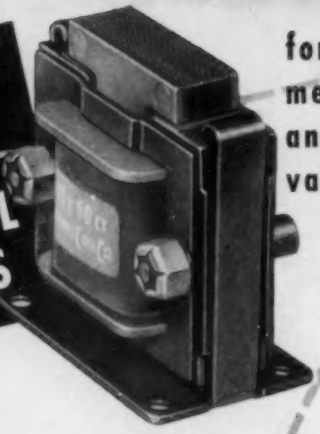
Decco

INDUSTRIAL SOLENOIDS



for small mechanisms and light valving

Decco gives you a complete range of small, short-stroke, low-amperage, push or pull Industrial Type Solenoids manufactured with all the high quality of Decco Standard Size Solenoids. Built to J.I.C. specification, Decco Small Solenoids are shock-mounted to reduce self-destruction, have silicon steel laminations for efficiency, hardened beryllium-copper plunger guide, and heavy Formvar insulated magnetic wire on high flow point molded nylon bobbins.

SPECIAL SOLENOID PROBLEMS ENGINEERED TO YOUR NEEDS

DETROIT COIL COMPANY

2435 HILTON ROAD • DETROIT 20, (FERNDALE) MICHIGAN

STAINLESS fasteners in STOCK

All types and sizes of screws (Phillips, slotted, hex head, socket), bolts, nuts, washers, rivets, keys and pins

- Over 9000 items in stock means *immediate delivery* from one source
- New Garden City plant now operating at top *speed and quality*
- Unsurpassed facilities for quantity fabrication of *specials*
- A staff of *seasoned* engineers always available for consultation
- *Pioneers* in the manufacture of stainless steel fasteners

WRITE NOW FOR FREE COPY OF FASTENER MANUAL P18

MANUFACTURERS SINCE 1929

ALLMETAL

SCREW PRODUCTS COMPANY, INC.

GARDEN CITY NEW YORK

FIRST FOR *Microscopic* PRECISION

OUR OBJECTIVE

TO MEET DESIGN NEEDS IN SMALL BEARINGS . . . . . by providing design engineers in this country with precision bearings of improved performance through techniques capable of volume production at Microscopic tolerances and sizes.

SPECIFY *Micro* BEARINGS

A MICRO FIRST in improved performance. Precision RETAINER Bearings. In 1950, MICRO introduced retainers to the small bearing field. By separating the balls with retainers higher speeds and lower friction is possible. MICRO was also first to provide ground outer races.

THE MICRO FAMILY OF RETAINERS ▼

ENLARGED 3 X

RIBBON RETAINER

CROWN RETAINER

MACHINED METAL RETAINERS

PHENOLIC PLASTIC

SPRING SEPARATOR

A MICRO FIRST

THE NEW RIBBON R2 DOES NOT WIND-UP HANG-UP OR FALL OUT

For Easier Mounting, Simplified Design and Lower Machine Costs, Specify Micro Flange Type

NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH, N. H.
MICRO CIRCLE TELEPHONE 424

Versatile pin does 4 jobs in a great new product!

SPIROL PIN — a pivot, a stop, a fastener and a reinforcement in the new DICTAPHONE Time-Master '5'

Engineers who designed Dictaphone Corporation's new dictating machine — "Time-Master 5" — found the new SPIROL pin so versatile that it could be used as a *pivot*, as a *stop*, as a *fastener*, as a *reinforcement* . . . a pin whose radial spring action would hold fast, yet could be easily removed without damage to either fastening or hole.

1. **SPIROL pins pivot** plastic control button and swinging microphone hook. SPIROL's all-around tension fits snugly in a *molded* hole in the plastic assembly, eliminating all drilling and reaming operations.

2. **SPIROL pin fastens** guide rod to frame. When compressed by insertion, pin exerts even *radial pressure* with no weak "hinge" lines — provides for easy removal and reinsertion in the field without damage to pin or hole.

3. **SPIROL pin reinforces** as well as fastens frame. Extends deep into frame, adding strength. Replaces more expensive dowel, saves a reaming operation.

4. **SPIROL 'stop'** controls movement of cam, absorbs shock better than solid pins. Available in standard sizes from 1/32" to 1/2" dia. and 1/8" to 4" length, or to specification.

Write for illustrated folder and sample SPIROL pins.

SPIROL PIN

C. E. M. COMPANY • 67 SCHOOL ST. • DANIELSON, CONN.

...give positive control of multiple complex circuits!

The versatility of Ledex Relays makes it possible to produce special switching combinations for specific applications. Stepping or selective controls are available depending upon the requirements. A wide range of operating voltages can be used by selecting the proper Ledex coil wire size.

HERE'S HOW A LEDEX RELAY OPERATES . . .

A LEDEX ROTARY SOLENOID provides the mechanical power to drive the gang of rotary, wafer type switches. SELECTIVE CONTROL —The commutating switch of the Ledex in combination with the control wafer switch makes it possible to select the multiple circuits to be connected by a single manually operated switch. RATCHETS are used to transmit the oscillating action of the Rotary Solenoid to the Relay rotor shaft. CIRCUIT WAFERS are produced in combinations of 8, 10, 12, 18 and 24 positions. All wafer sections are versatile in application. For example the 12 position wafer switch may be designed to utilize almost any of the factors of 12 such as 1P-12T, 2P-6T, 3P-4T, or 4P-3T. The clips and rotors of the wafer switches are of silver alloy. For most applications the switch insulation is of wax-impregnated bakelite. Ledex Relays are available with foot, flange or panel mountings.

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SOMETHING NEW!

SEE PAGE 317

U.S. Army Photograph

Quick on the bull's-eye and stay there

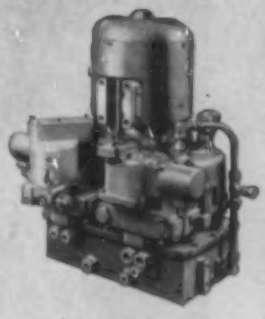
WITH OILGEAR FLUID POWER

Meeting speed, control and precise performance requirements of today's U. S. Tanks, Howitzers and Anti-Aircraft Guns is a "Natural" for Oilgear ANY-SPEED Fluid Power Components.

Gunners in Sherman, Pershing and Patton tanks experienced the advantages of rapid fluid power slewing and precise fluid power tracking of the turret and gun 360° in either direction. They appreciated the value of Oilgear fluid power that obeyed a light twist of the wrist. Likewise, those manning America's most effective 40 mm anti-aircraft guns, recognized the importance of automatic, self-synchronizing Oilgear fluid power drives for rapid slewing and precise tracking of the carriage 360° in either direction and the rapid, accurate elevating and depressing of the gun for quick homing on the target and following it.

Therefore, when today's new combat vehicles with far greater fire power and accuracy were planned, Oilgear ANY-SPEED Fluid Power Drives were a "Natural" for both turret traverse and gun elevation. They met the demands for accurate control over speed ranges up to 4000:1. They provided unbelievably low tracking speeds under precise response without overrun or drift. They stayed on the target for repetitive shots. No wonder, one men's magazine calls the new Oilgear equipped M47 "the sharpest shooting tank anywhere today." That's why Oilgear ANY-SPEED fluid power drives are a "Natural" on the wide variety of U. S. combat vehicles.

Don't you think it is time for you to look with wide open eyes at Oilgear Fluid Power Pumps, Motors and Transmissions for your machines . . . to better the performance of an already good machine? To solve a seemingly "impossible" design problem? To synchronize machine units easily and economically? To weed out trouble and cut maintenance and down time to a surprisingly low level? Counsel with an Oilgear Engineering Representative will cost you nothing, may benefit you greatly. THE OILGEAR COMPANY, 1571 W. Pierce St., Milwaukee 4, Wisconsin.



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Self-contained unit used in present day tanks and howitzers. Consists of electric drive motor, two Oilgear two-way variable delivery pumps (or generators), oil reservoir and integral closed system controls for turret traverse and gun elevation. Supplies fluid power to Oilgear hydraulic drive motors.

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Beryldur-

A NEW, LOW-COST, EASY-TO-WORK BERYLCO BERYLLIUM COPPER ALLOY

Why make a dustpan out of beryllium copper? In this case, the pan had to be nonsparking, yet stronger and harder than would be possible with brass or bronze. In fabricating the pan from Beryldur, a brand-new Berylco beryllium copper alloy, the makers demonstrated the workability of this new low-cost material.

Beryldur .035" thick was supplied in the annealed temper. In this condition, Beryldur is easy to form, as the illustration shows. The handle was roll formed and punched; the body stamped, drawn, punched, crimped and coined. The same dies used for making steel pans were employed without modification. The pan was then hardened by a simple low-temperature heat treatment to an ultimate tensile of 125,000 to 140,000 psi.

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The properties of Beryldur are midway between those of high-strength and high-conductivity Berylco alloys. Beryldur therefore has higher tensile strength than brass or bronze, plus high fatigue strength, great resistance to wear, and good electrical conductivity.

Now for the first time, Beryldur makes available the outstanding properties of beryllium copper at lower prices. Remember, too, you save not only in initial cost, but through reduced fabrication costs and reduction of rejects. For sample material or engineering help, call or write any of the offices listed below.

FURTHER INFORMATION ABOUT BERYLDUR is contained in this 4-page folder. Send for your free copy today.

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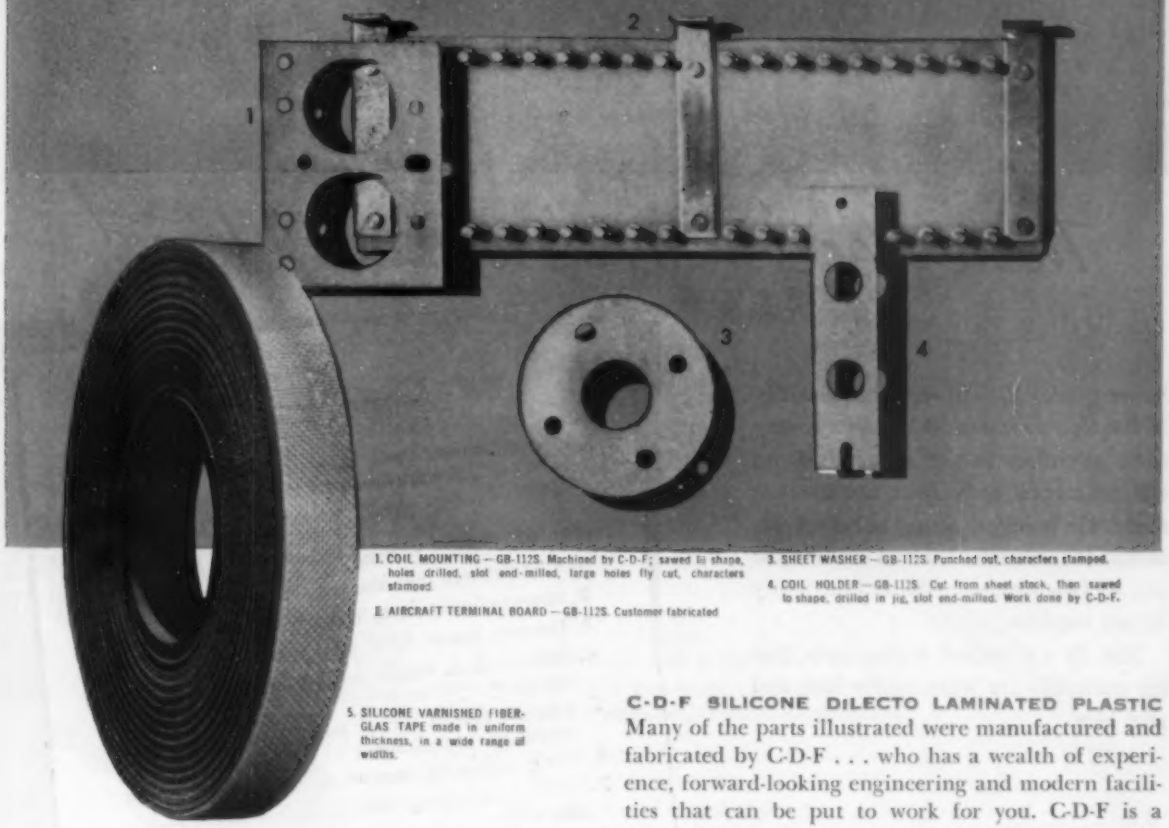

1. COIL MOUNTING — GB-112S. Machined by C-D-F; sawed to shape, holes drilled, slot end-milled, large holes fly cut, characters stamped.

2. AIRCRAFT TERMINAL BOARD — GB-112S. Customer fabricated

3. SHEET WASHER — GB-112S. Punched out, characters stamped.

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THE NAME TO REMEMBER... CDF SILICONE TAPES, SHEETS, TUBES, RODS

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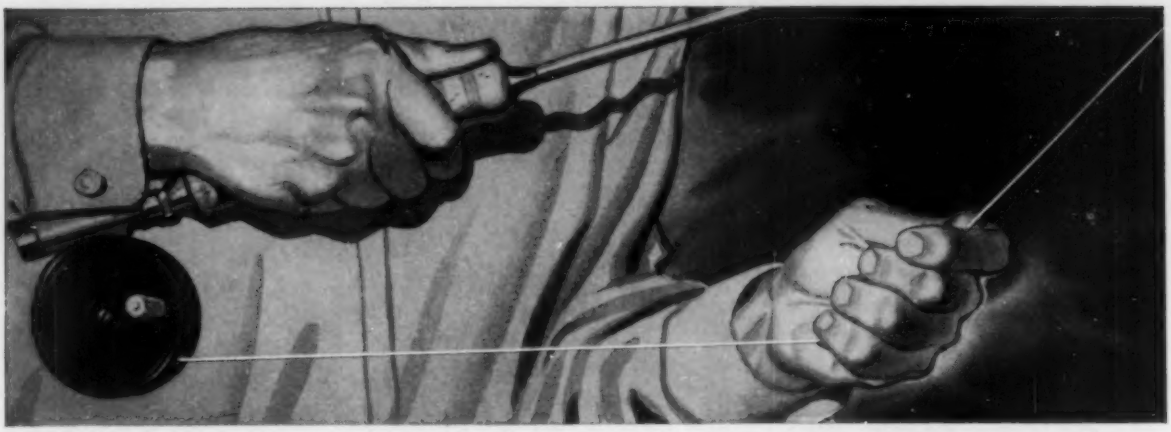

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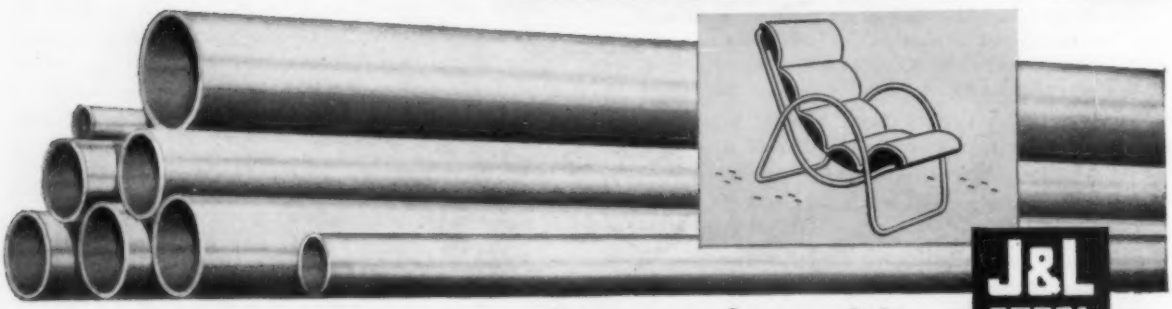

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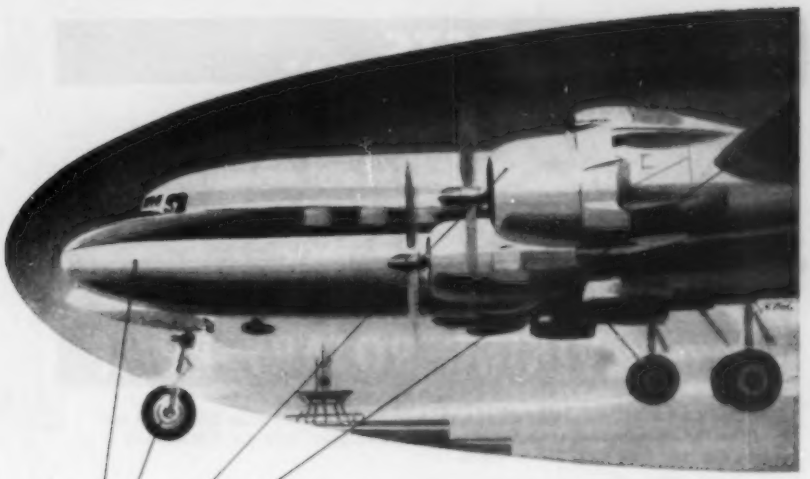

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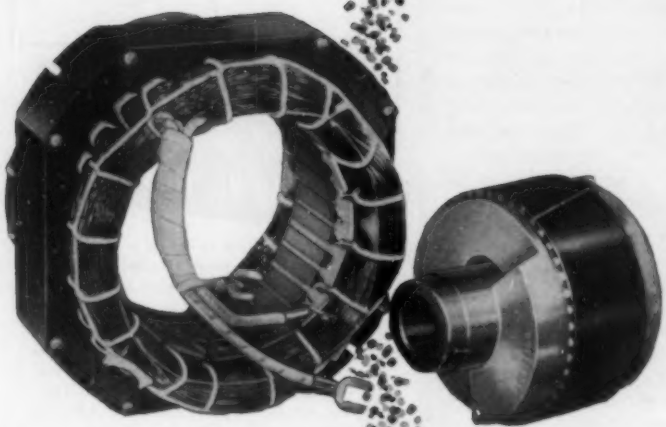

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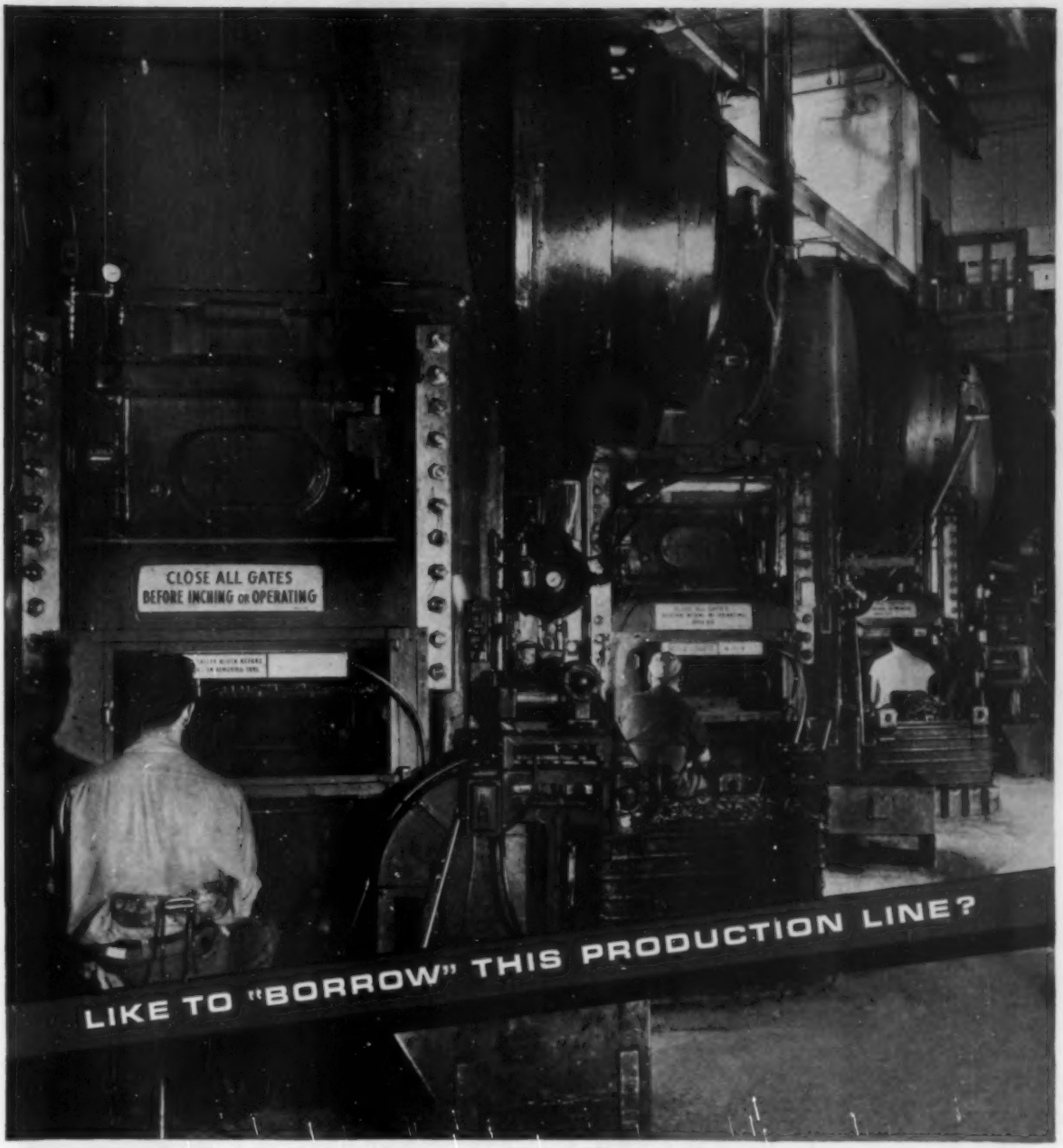

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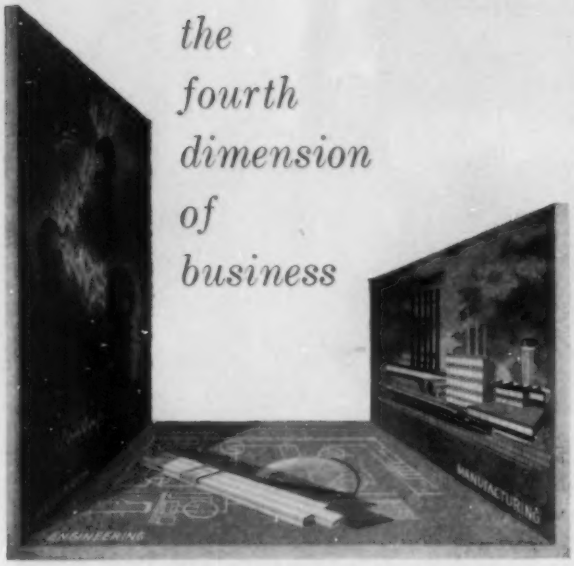

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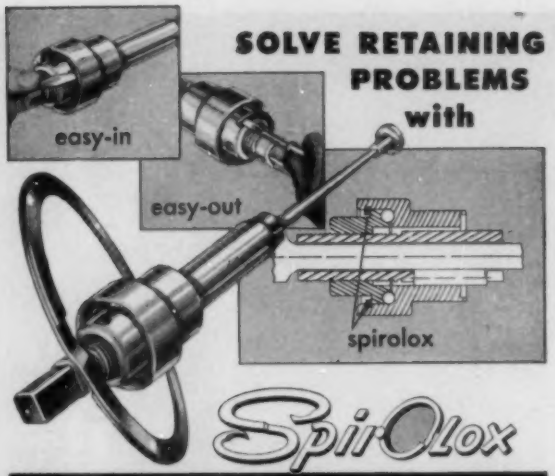

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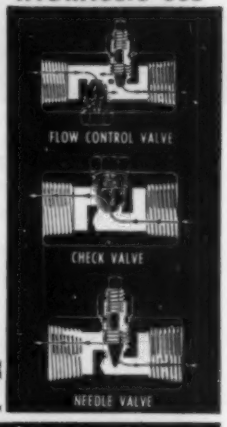

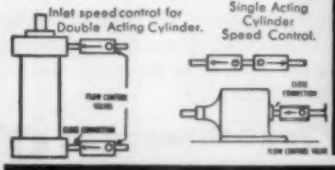

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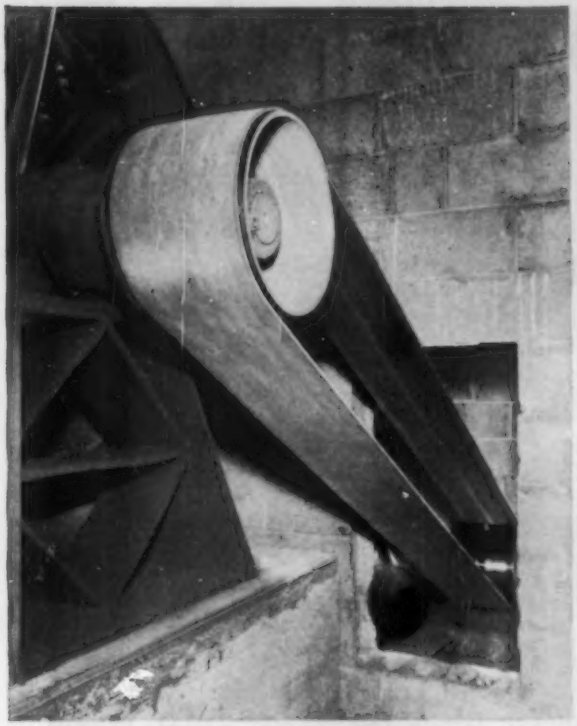
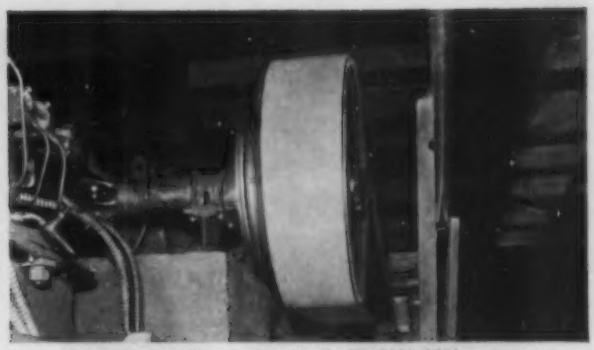
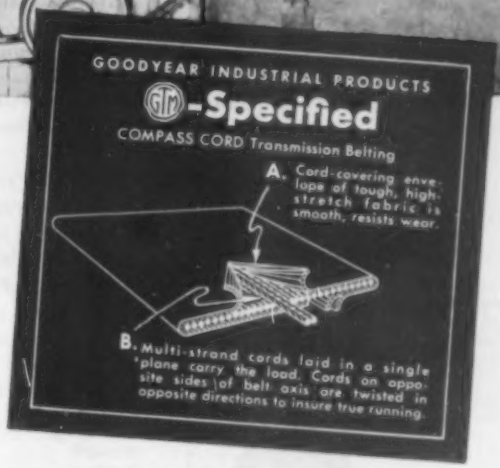


Chassis Dynamometer No. 2: COMPASS CORD #40 Transmission Belt on combined cooling and loading fan drive



Chassis Dynamometer No. 1: COMPASS CORD #40 Transmission Belt on cooling air fan drive

Chassis Dynamometer No. 1: COMPASS 250 Steel Cable Transmission Belt on loading fan drive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G.T.M.-Specified
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A. Cord-covering envelope of tough, high-stretch fabric is smooth, resists wear.
B. Multi-strand cords laid in a single plane carry the load. Cords on opposite sides of belt axis are twisted in opposite directions to insure true running.

HERE's another tough design problem solved by the G.T.M.—Goodyear Technical Man:

Engineers at Gulf Research & Development Company could not find the right belts to drive cooling air and loading fans on chassis dynamometers used to determine friction and wear in automobile engines. These fans cool the vehicle engine and duplicate air resistance of the car at speeds up to 75 mph on day-in, day-out, year-long test runs.

The drives had to be flexible, reliable and smooth-running. All the belts tried failed in three or four months or caused excessive vibration. Then, the G.T.M. specified endless COMPASS CORD Transmission Belts. These round-and-round-constructed, precisely balanced belts have been running well over four years—average 65,000 test miles per year—with no trouble.

See the G.T.M. for a similar solution to your drive problems or on any other use of industrial rubber goods.

Goodyear, Industrial Products Division, Akron 16, Ohio

YOUR GOODYEAR DISTRIBUTOR *can quickly supply you with Hose, Flat Belts, V-Belts, Packing or Rolls. Look for him in the yellow pages of your Telephone Directory under "Rubber Products" or "Rubber Goods."*

Compass—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

GOODYEAR

THE GREATEST NAME IN RUBBER

We think you'll like "THE GREATEST STORY EVER TOLD"—every Sunday—ABC Radio Network—THE GOODYEAR TELEVISION PLAYHOUSE—every other Sunday—NBC TV Network

Production costs cut 90%

WITH GRAY IRON

Gear cover fabricated from nine pieces. Arrows show cut-outs.

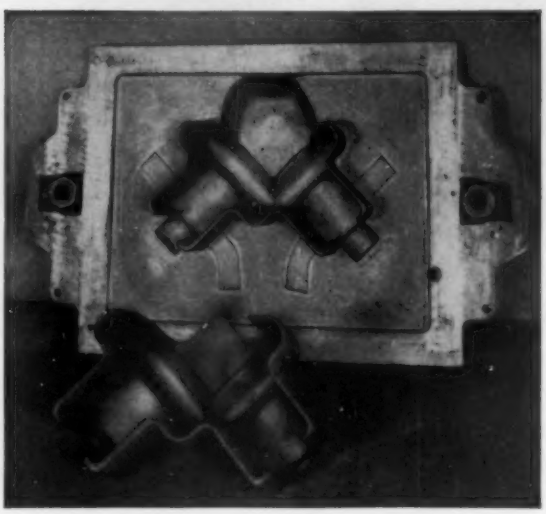
Made entirely in green sand, the Gray Iron castings were produced at one-tenth the cost of fabricated gear cover.

Formerly, nine separate pieces were shaped and welded into a fabricated gear cover for a braiding machine. Then, the manufacturer redesigned the gear cover for production in Gray Iron.

The finished and machined casting cost *less than 10%* of the production cost for the fabricated piece. This saving quickly paid for pattern-equipment costs . . . netting a *90% saving* on all parts thereafter. By redesigning for Gray Iron, the manufacturer not only made substantial savings, but obtained the advantages of a streamlined, vibration-absorbing gear cover.

Look at the structural and functional requirements of your fabricated parts. You can undoubtedly use the unique characteristics of Gray Iron—and the economy offered by this casting process. Why not write us for more information?

Matchplate and gear cover.



GRAY IRON CHARACTERISTICS INCLUDE:

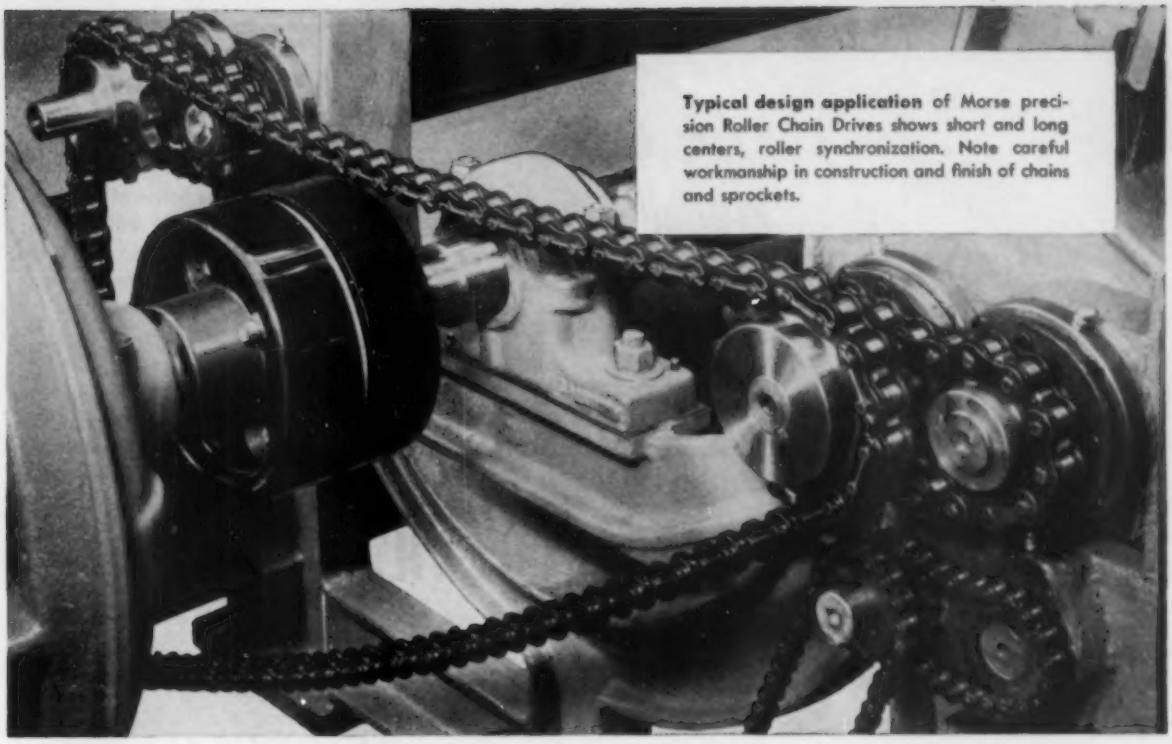
Castability	Low Notch Sensitivity	Corrosion Resistance
Strength	Wear Resistance	Durability
Rigidity	Heat Resistance	Vibration Absorption
	Machinability	

MAKE IT *BETTER* WITH GRAY IRON

75% of all cast metal products are Gray Iron

GRAY IRON FOUNDERS' SOCIETY, INC.

NATIONAL CITY-E. 6th BLDG., CLEVELAND 14, OHIO



Typical design application of Morse precision Roller Chain Drives shows short and long centers, roller synchronization. Note careful workmanship in construction and finish of chains and sprockets.

Get nearly 99% efficiency throughout the long life of your drives

Whether your problem is transmitting fractional or extremely heavy horsepower, Morse precision Roller Chains and Stock Sprockets can help you.

Morse precision Roller Chains are noted for excellent workmanship and accuracy, resulting in long, trouble-free service life. There is positive power transmission with Morse precision Roller Chains, with *nearly 99% efficiency throughout their entire life.* Coupled with Morse Stock Sprockets, they make an excellent power transmission team; one which reduces both downtime and maintenance.

Rollers on Morse precision Roller Chains are shot peened and heat treated for maximum strength and endurance. They are held to close limits to provide even distribution of the load.

When Morse precision Roller Chains and Stock Sprockets go to work, you gain in off-the-shelf service and design flexibility. Morse precision Roller Chains save space by transmitting more usable power than many other types of power transmission drives. They operate equally well on short or long centers, and mesh with sprockets on either side of the chain to drive multiple sprockets for accurate timing. You realize production economies through greater permissible center distance tolerances and greatly increased ease of assembly.

Be sure to call in your Morse sales engineer on *every* power transmission problem. He is a qualified power transmission specialist and can bring the latest information and specialized engineering aid to you. Write us today for further information. Morse Chain Company, 7601 Central Ave., Detroit 10, Michigan.

MORSE

MECHANICAL POWER TRANSMISSION PRODUCTS

FOR 24 REASONS, MASTERS OF MECHANICAL POWER TRANSMISSION SINCE 1893

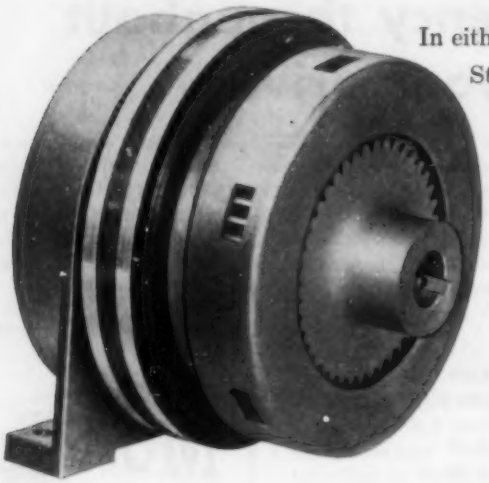
Be Sure with a

Matched-to-the-Machine

STEARNS MAGNETIC CLUTCH

On many machines, a standard magnetic clutch does the job.

On others, however, a special custom-made unit is needed for the most profitable results.



In either case, you're right with Stearns — because this pioneer in magnetic equipment builds both.

Here are important reasons why Stearns magnetic clutches provide positive dependable control on such a wide variety of applications.

- *Torque range from .4 to 30,000 lb. ft.*
- *Low inertia — fast, smooth engage and disengage. Split shaft, through shaft, two speed drives, forward and reversing drives — other special applications.*
- *Quiet and cool running. No metal-to-metal contact, no sparking.*
- *Automatic or manual control.*
- *No toggles, yokes, shifters.*
- *Simple adjustment.*

Let Stearns' design and engineering experience work for you. Consult your Sweet's Product Design File or write for bulletin 226-C-2.

1083

MAGNETIC EQUIPMENT FOR ALL INDUSTRY

STEARNS MAGNETS

STEARNS MAGNETIC, INC.

631 South 28th Street, Milwaukee 46, Wisconsin

Your next HANDBOOK of Product Design . . .

has been in preparation since last November. It will be published in October, and will come to you as part of your regular subscription to *Product Engineering*.

The 1955 HANDBOOK, like the first two HANDBOOKS of 1953 and 1954, will bring you a broad assortment of data covering every field of product-engineering. This data . . . authoritative, complete, and thoroughly illustrated . . . will be sectionalized into ten major areas of your interests:

General Engineering

Metals and Alloys

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Fabrication and Production Processes

Power Transmission

Mechanical Parts and Design Analysis

Fastening and Joining

Motors, Engines, and Controls

Electrical and Electronic Components

Hydraulic and Pneumatic Equipment

In addition to new data covering all significant developments of the year in product-design engineering, you will find many informative, specially prepared advertisements appropriately following each individual section in the HANDBOOK.

Product Engineering

McGraw-Hill Building
New York 36, N. Y.

STANDARD PINION DIMENSIONS
STANDARD GEAR SETS (RIGHT HAND) TOOL CHARTS & HORSEPOWER
STANDARD GEAR SETS (RIGHT HAND) TOOL CHARTS & HORSEPOWER RATINGS (Cont'd)
STANDARD BRONZE GEAR BLANKS
GEARING TYPE) AND SPIDER STANDARDS

plus **this vital feature**

Standard *Cone-Drive gears and worms are carried in stock. Cone-Drive gears are noted for their long life—BUT if a failure should occur at any time, replacement gears and worms are available without delay.*

Ask for Catalog No. 700

Specify STANDARD Cone-Drive Gears and get all these advantages

Lower Cost—due to smaller size of gears and housings, mass production of worm and gear blanks, etc.

Compactness—due to distribution of load over greater contact area, reducing unit pressures. As a result, gear sets can have smaller center distances, enclosures can be smaller, etc.

Less Weight—due to smaller center distances for a given horsepower or torque. Other types of gearing weigh up to 3 times as much for the same horsepower transmitted.

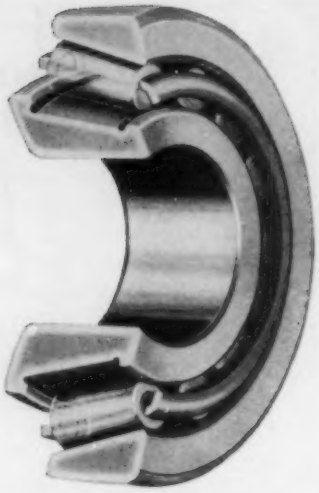
Greater Smoothness—because Cone-Drive gears have more teeth in continuous contact than other forms of gearing.

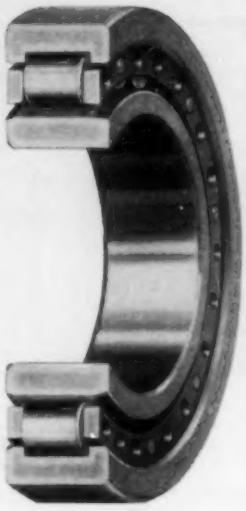
Wide Range of Sizes—Center distances from 2″ to 18″ provide horsepower ratings from fractional up to 800 horsepower. Ratios range from 5/1 to 70/1.

CONE-DRIVE GEARS
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
Division Michigan Tool Company
7171 E. McNichols Road • Detroit 12, Michigan

WHATEVER YOUR ROLLER BEARING APPLICATION

specify BOWER!





Earthmovers, jet turbine engines, rolling mill equipment, truck axles—you name it! Bower builds a complete line of tapered, straight and journal roller bearings including a size and type to fit *your* product. What's more, these dependable bearings have *proved* themselves in virtually every conceivable type of application. Their built-in quality, skillful engineering and advanced design features provide such important bearing advantages as reduced wear, longer life and lower maintenance requirements. Let a Bower engineer give you full details on the complete Bower line.

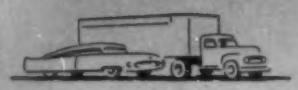
BOWER ROLLER BEARING COMPANY
DETROIT 14, MICHIGAN

BOWER TAPERED ROLLER BEARINGS INCORPORATE ADVANCED SPHER-O-HONED DESIGN! Spherically generated roll heads and higher flange with larger, two-zone contact area reduce wear, improve roller alignment and virtually eliminate "end play." This helps hold adjustment and pre-load longer and better. Larger oil groove provides positive lubrication.

BOWER STRAIGHT ROLLER BEARINGS ARE BUILT TO CARRY MAXIMUM LOADS! Integral two-lip race increases rigidity—keeps rollers in proper alignment at all times. Steel cage allows free movement of rollers between races during normal operation. High-grade alloy-steel rollers and races are precision-ground for quieter, smoother operation.

A COMPLETE LINE OF TAPERED, STRAIGHT AND JOURNAL ROLLER BEARINGS
for every field of transportation and industry

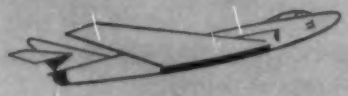
AUTOMOTIVE



RAILROAD

FARM

AIRCRAFT



EARTHMOVING

INDUSTRIAL

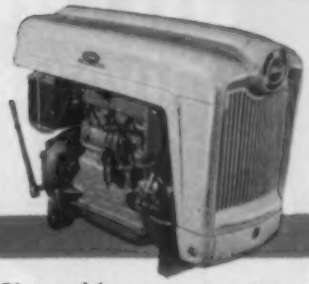
BOWER ROLLER BEARINGS

SPHER-O-HONED

Here's Big News!

FORD'S LATEST "172" CU. IN. ENGINE

★ OVERHEAD-VALVE
★ LARGE BORE
★ SHORT-STROKE
★ DEEP RIGID BLOCK



Pictured here are two types of sheet metal available with this Ford "172" 4-Cyl. Power Unit. Either type can also be specified with the Ford "134" 4-Cyl. Power Unit.

Ford
INDUSTRIAL ENGINES
AND POWER UNITS

Here is another Ford power plant of the most modern large bore, short-stroke, low-friction design . . . engineered, built and tested *exclusively* for *industrial* applications!

This new Ford engine delivers the mightiest concentration of power *per cubic inch* of any engine of comparable size and weight. With only 172 cu. in. displacement, this 4-cylinder engine attains a maximum of 58 brake horsepower at 2400 rpm. Less displacement normally requires less gas which means greater daily operating economy. Other outstanding features of this new Ford "172" Heavy Duty Industrial Engine are listed below.

Glance through them now and don't hesitate to ask or write for a detailed folder with complete specifications or any other information on the latest in engine design. *Write to:*

INDUSTRIAL ENGINE DEPARTMENT
FORD MOTOR COMPANY
15050 Woodward Avenue, Highland Park 3, Michigan

Features that Provide Highest Performance and Outstanding Economy

Large bore (3.90 in.) combined with *short stroke* (3.60) cuts piston travel, reduces friction, delivers more power at clutch and reduces fuel costs.

Deep-skirted crankcase is a feature that provides high structural rigidity for more efficient operation and longer life.

Precision-molded alloy iron crankshaft, fully counter-balanced in motion with mirror-like bearing surfaces that reduce friction to a minimum.

Free-turn valves (intake and exhaust) for even wear to help maintain high compression for longer than average period and reduce the possibility of valve sticking.

Weather-proofed ignition provides molded rubber integral seals for all spark plug terminals and lead wires. Distributor also tightly sealed against dust and dampness.

Full-flow oil filter with full-pressure lubrication contributes to longer engine life.

Autothermic pistons of cam-ground aluminum alloy with steel struts for controlled piston-to-sleeve clearance.

Full-length water jackets surrounding each cylinder to maintain uniform temperature, which in turn minimizes bore distortion and reduces wear.

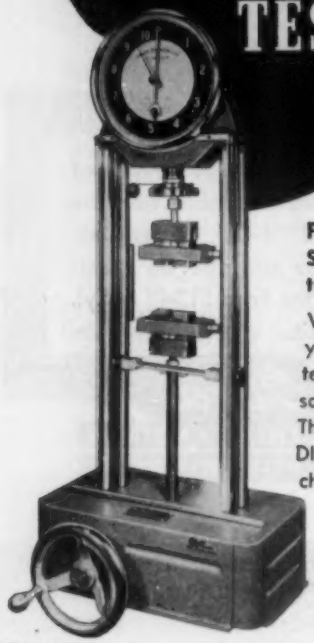
Fast-acting, fully lubricated, variable speed governor is mounted on crankshaft as an integral part of engine.

Every Ford Industrial Engine from 134 cu. in. to 317 cu. in. is a complete, precision-built "Power Package," delivered fully equipped, tested and ready-to-run. All are available as Engine Assemblies or Complete Power Units with a wide variety of accessories and adaptations to fit your job.

Guess Work Can Cost You Money!

Get accurate engineering data quickly with a

DILLON Universal TESTER



Motorized or hand operated Portable.

For Flat, Round or Special Shapes in all types of materials . . .

With a DILLON TESTER you can do all your own testing in your own plant; saving time and money. There are seven different DILLON gauges, all interchangeable to handle materials with tensile strength as low as .25 lbs. or as high as 125,000 lbs. P.S.I.

DILLON UNIVERSAL TESTERS are compact, ruggedly built, accurate instruments. They are fast and easy to operate—even by untrained help.

DILLON TESTERS are used throughout the world by modern industry because they are economical and dependable, and built to last a lifetime.

Each DILLON TESTER is individually calibrated with an elastic proving ring. These rings are certified by the United States Bureau of Standards and are accurate to within 2/10 of 1%. In actual calibration, the ring is placed in direct series with the Dynamometer gauge. Stress curves are made by highly experienced technicians. Every instrument is individually checked.

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let's talk **TORQUE**

IN TERMS OF TORQUE—

Crosscurving means longer, smoother, more even delivery of power

You get Dual Power when you use Sandsteel's "Crosscurved" mainsprings in your products. The "Crosscurved" spring tends to expand in the direction in which it is tempered and the crosscurve, which at full wind is partly flattened out, stores additional energy. You get more energy per wind and a smoother, more even energy distribution. This results in superior performance, greater accuracy and longer life for your product. The "Crosscurved" mainspring is original with Sandsteel—means better engineering . . . greater efficiency. Investigate the possibility of using Sandsteel "Crosscurved" mainsprings in your product. We shall be pleased to advise you.

Write for our FREE brochure—"Sandsteel Springs for Your Products"—Dept. 92

SANDSTEEL SPRING DIVISION
SANDVIK STEEL, INC.
145 HUDSON STREET, NEW YORK 13, N. Y.

HERE'S THE STRONGEST BRONZE

HY-TEN-SL
A Bronze as Strong as Nickel Steel

TRADE-MARK

Grade of HY-TEN-SL	1AA	1A	1	2	3	4
TENSION						
Ultimate tensile strength lbs. per sq. in.		(Minimums)				
Sand Cast	125,000	115,000	108,000	100,000	90,000	85,000
Rolled 1" and under	.....	120,000	110,000	105,000	95,000	85,000
Rolled or Forged, over 1"	.....	115,000	108,000	100,000	90,000	85,000
Yield Point (divider method)						
Sand Cast	95,000	75,000	60,000	55,000	45,000	40,000
Rolled 1" and under	.....	75,000	65,000	60,000	50,000	45,000
Rolled or Forged, over 1"	.....	75,000	65,000	60,000	50,000	45,000
Elongation in 2"—%						
Sand Cast	10	12	13	13	20	25
Forged or Rolled	.....	12	13		15	20
Reduction in area—%						
Sand Cast	.....	12	14	13	20	25
Forged or Rolled	.....	12	13		15	20
COMPRESSION						
Yield Point—lbs. per sq. in.	70,000	65,000	58,000	50,000	40,000	35,000
Permanent Set at 100,000 lbs. per sq. in. (max.)	.015	.020	.030	.050	.080	.125
Brinell hardness, NO.	250	240	220	200	175	150

List of U. S. Government Specifications Covering HY-TEN-SL Bronze

ARMY
Forgings, Rolled Rod QQ-B-721 Class B
Castings...QQ-B-726 Class B and C

NAVY
Forgings and Rolled Rod 46B15, Class B
Castings, Aluminum-manganese Bronze 46B29

WATERTOWN and OTHER ARMY ARSENALS
Castings WXS-5
Forgings and Rolled Rod.....WXS-2

NAVAL GUN FACTORY
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Castings—Trunnion Metal.....O.S.350

AIRCRAFT
See Navy and Army (above).

Send for 46 Page "Text Book"

AMERICAN MANGANESE BRONZE COMPANY

4705 RHAWN ST., HOLMESBURG, PHILADELPHIA 34, PA.

Established 1909

EVEN THE BEST CAN BE IMPROVED

Gerotor offers its New QDB series of small capacity pumps as proof!

Gerotor has redesigned its series of small capacity pumps to give even more . . .

- **FLEXIBILITY**—the QDB can be operated in either clockwise or counterclockwise direction by simply changing the position of one internal plug!
- **RANGE OF APPLICATION**—the QDB can be obtained with an extended shaft to operate another pump in tandem, off of one motor!
- **DEPENDABLE SERVICE**—the QDB is built to give more dependable service over a longer service span than any comparable pump. Its longer life reduces your maintenance and replacement costs.

If you have need for pumps in the QDB range, call on Gerotor.

Gerotor makes a complete line of hydraulic pumps in ranges from .4 g.p.m. to 40 g.p.m. The Gerotor engineers can help you solve your hydraulic pump problems. Write for *free literature* and full particulars.

Check this capacity table . . .

Type	Delivery g.p.m.—1800 r.p.m.				
	Discharge Pressure p.s.i.				
	0	250	500	750	1000
QDB .4	.42	.40	.38	.35	.31
QDB .75	.84	.80	.78	.73	.66
QDB 1.5	1.67	1.62	1.57	1.50	1.42

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HYDRAULIC PUMPS & MOTORS

power

for the popular new
VEE-D-X
antenna rotator is

a LOYD SCRUGGS motor... tailor-built for the job!

The advanced styling and precision design of the rugged VEE-D-X rotator . . . most outstanding on the market . . . demanded the utmost in motor performance. To meet the exacting requirements of LaPointe Electronics, Inc., Scruggs designed this low-voltage AC reversible capacitor-type motor.

Take a tip from VEE-D-X...

and other leading manufacturers. Get the Inside Story on Scruggs Motors . . . and learn how we can help you develop better products. We will build a motor to fit your specific requirements without obligation. For complete information write the Loyd Scruggs Co., 1022 N. 6th St., St. Louis 1, Mo.

You can stake your reputation on SCRUGGS MOTORS
Also manufacturers of shaded pole, DC, and AC-DC motors.

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A Dazey Corporation Subsidiary
MANUFACTURERS OF PRECISION INSTRUMENTS SINCE 1934

The NEWEST development in V-ring packings

LINEAR VEE-DAM* RINGS

Foolproof to assemble . . . leakproof in operation

Moulded-in rubber dams seal off labyrinth and lateral flow, even when gaps occur in the ring joint through faulty installation. Precision moulded of fabric-reinforced synthetic rubber. Write for details.

*Patent Pending

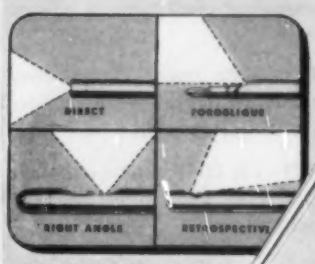
"PERFECTLY ENGINEERED PACKINGS"

LINEAR

LINEAR Inc., State Rd. & Levick St., Philadelphia 35, Pa

A.C.M.I. BORESCOPES

for close-up visual inspection of internal surfaces and hidden parts



A.C.M.I. Borescopes are available in 4 angles of vision (as above)—in diameters of .120" to 4.00"—in lengths of 4" to 720". Special models for special problems.

A.C.M.I. Borescopes permit close-up visual examination of interior areas and surfaces not otherwise visible. They save time and money, and prevent costly dismantling.* Each Borescope is a compact, self-illuminated industrial telescope of highest quality, employing a precision optical system, that produces a flat visual field. Lens systems are fully corrected for color, spherical aberrations, and coma, with all lens surfaces coated to increase light transmission

Write for free informational folder, or tell us your problem.

American Cystoscope Makers, Inc.
1241 LAFAYETTE AVENUE NEW YORK 59, N. Y.

Which of these is your pumping problem?

Name just about any fluid you consider "hard to handle" and we will show you a De Laval pump that will do the job efficiently and at low cost.

De Laval IMO and CPO pumps have solved problems on a wide range of products—hot or cold, acidic or alkaline, viscous or corrosive, clear or filled with suspended solids. IMO and CPO models are available for early delivery.

Your De Laval representative is an experienced application engineer. Consult him on your pumping problems.

DE LAVAL IMO PUMPS
capacities to 750 gpm
pressures to 1500 psig
Write for Bulletin LG-A

DE LAVAL CPO PUMPS
capacities to 2000 gpm
heads to 200 feet
Write for Bulletin 1125-B

DE LAVAL *Pumps*

DE LAVAL STEAM TURBINE COMPANY
801 Nottingham Way, Trenton 2, New Jersey

DL 236A

GLOBE Seamless
GLOWELD Welded

- **Resistance to Corrosion**
- **Strength at High Temperatures**
- **Resistance to Oxidation at High Temperatures**
- **Ease of Fabrication**

TYPICAL ANALYSES AND TYPES:

302	309S	316Cb	330	410
302B	309Cb	317	347	430
304	310	321	403	443
308	314	329	405	446
309	316	INCONEL * — NICHROME **		

**Registered U.S. Trade-Mark* ***Trade-Mark Reg. U.S. Pat. Off. D-H Co.*

Globe produces more than 26 standard analyses of stainless steel tubes — also special analyses when required. Because varying analyses have widely varying service characteristics, Globe will make recommendations only after careful study of your particular problem.

GLOBE

specialization...

meets your exact requirements in

STAINLESS STEEL TUBES

Write for Bulletin 333 — Corrosion and Heat Resisting Steel Analyses Chart — a valuable reference tabulation of stainless steel analyses as produced by various manufacturers.

Piercing, rolling and reduction of seamless tubes is closely monitored from this control room — typical of the highly specialized equipment in the Globe mill.

SIZE RANGE:

Globe seamless stainless steel tubing may be had in sizes from ½ inch to 6 inches O.D., and in pipe sizes ⅛ inch to 6 inches, standard, extra strong and double extra strong weights.

Gloweld electric welded stainless steel tubing is available in sizes ranging from ¼ inch to 5 inches O.D. inclusive; in standard weight pipe (schedule 40) sizes ⅛ inch to 2 inches — lightweight pipe (schedule 5 and 10) ⅛ inch to 4½ inches inclusive.

TOLERANCE RANGE:

All stainless tubing furnished to standard A.S.T.M. specifications unless otherwise specified to suit your particular application requirements.

Globe specialization gives you uniform high quality...

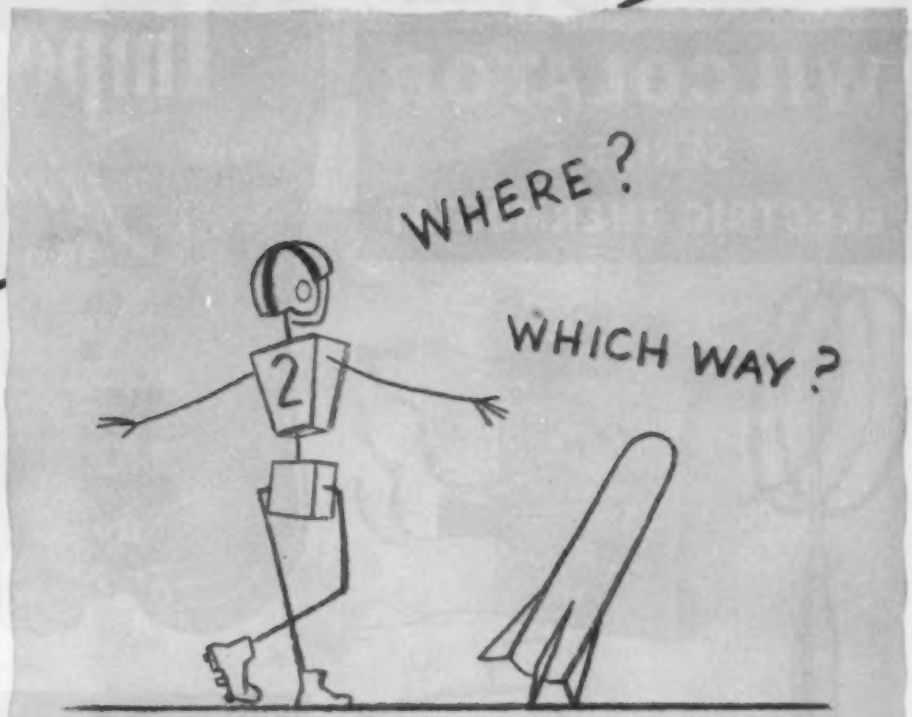
Precision checks — and re-checks — at every stage of production insure Globe stainless steel tubes that meet *your* exacting specifications. For more than thirty years, specialization in production of steel tubes has key-noted all Globe research, engineering and mill operations. Write for the Globe Stainless Steel Tubes catalog.

GLOBE STEEL TUBES CO., Milwaukee 46, Wis.

Chicago — Cleveland — Detroit — New York — Philadelphia — St. Louis — Denver — Houston — San Francisco — Glendale, Cal.

Producers of Globe seamless stainless steel tubes — Gloweld welded stainless steel tubes — alloy — carbon seamless steel tubes — Globeiron (high purity ingot-iron) seamless tubes — Globe welding fittings.

HOW TO KICK OFF A ROCKET
in the right direction



...and FORD was asked to find the answer

Load! Aim! Launch! And off goes a rocket from shipboard . . . but not without precise devices that start the rocket in the right direction. Devices . . . such as Ford Instrument has manufactured for the Armed Forces since 1915. For from the vast engineering and production facilities of the Ford Instrument Company, come the mechanical, hydraulic, electro-mechanical, magnetic and electronic instruments that bring us our "tomorrows" today. Control problems of both Industry and the Military are Ford specialties.

14

You can see why a job with Ford Instrument offers young engineers a challenge. If you can qualify, there may be a spot for you in automatic control development at Ford. Write for brochure about products or job opportunities. State your preference.

FORD

FORD INSTRUMENT COMPANY
DIVISION OF THE SPERRY CORPORATION
31-10 Thomson Avenue, Long Island City 1, N. Y.

FOR **HIGH** ACCURACY

AT **LOW** COST

WILCOLATOR

SERIES E

ELECTRIC THERMOSTAT

For all remote control applications where a single pole, slow make and break thermostat may be used, you get excellent sensitivity, close temperature control with this high quality thermostat.

Actuated by liquid expansion, the Series E Thermostat is one of the latest developments of Wilcolator, makers of quality precision controls since 1926.

RATING: 15 amp. 240 volts
20 amp. 120 volts

TEMPERATURE RANGE: 30°F. to 550°F.

Available in various combinations of temperature ranges, with suitable bulbs and capillary tube lengths.

Use it with:

Room Heaters
Roasters
Small Bake Ovens
Rangette Ovens
Water Heaters
Warming Cabinets
Mangles—Ironers
Brooders
Incubators
Sterilizers
etc.

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THE Wilcolator COMPANY

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Write in margin of this page name of type screw in which you are interested, and bulletin will be sent you promptly, without charge or obligation.

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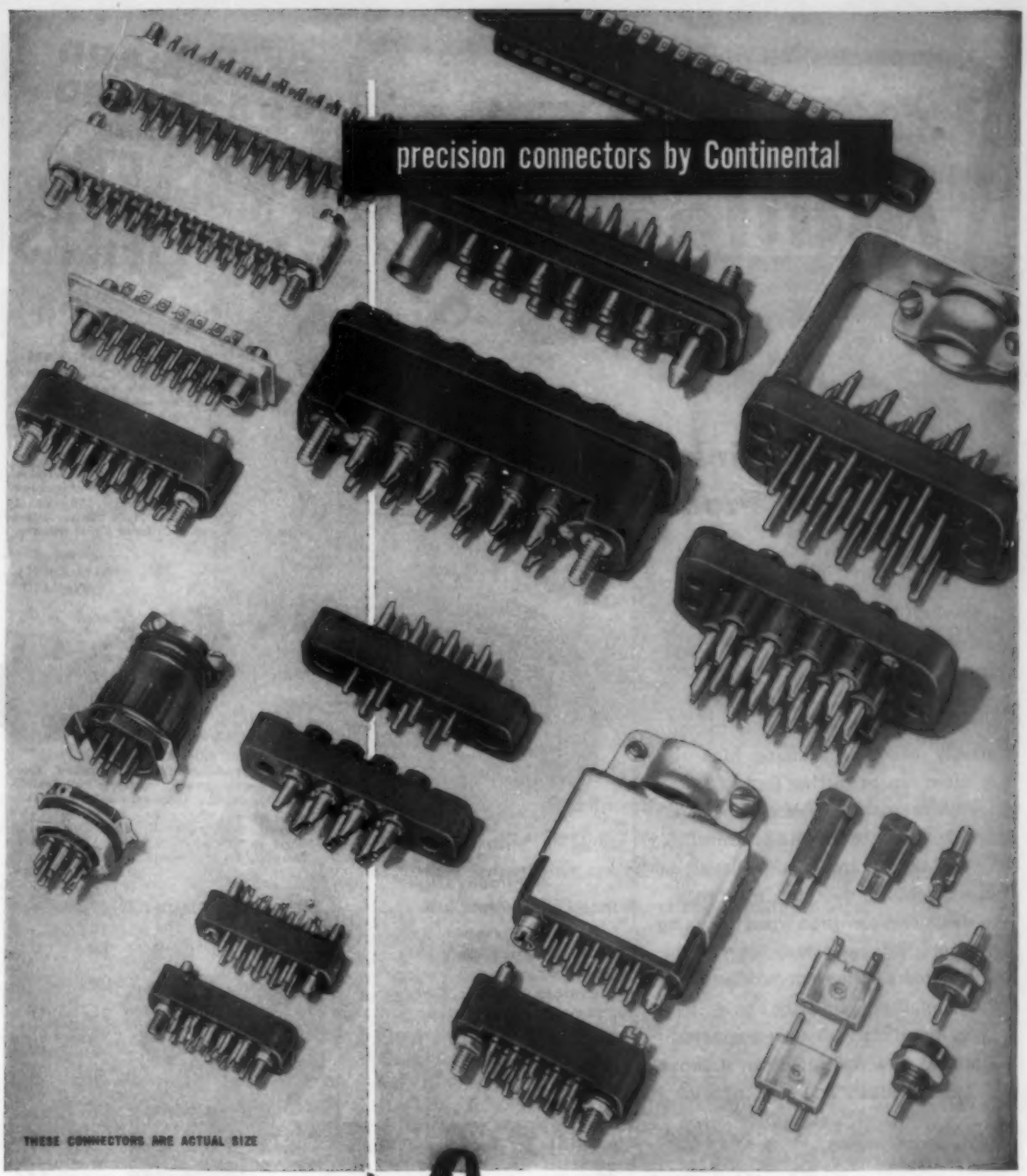
We Specialize in Solving Puzzling Set-Screw Problems



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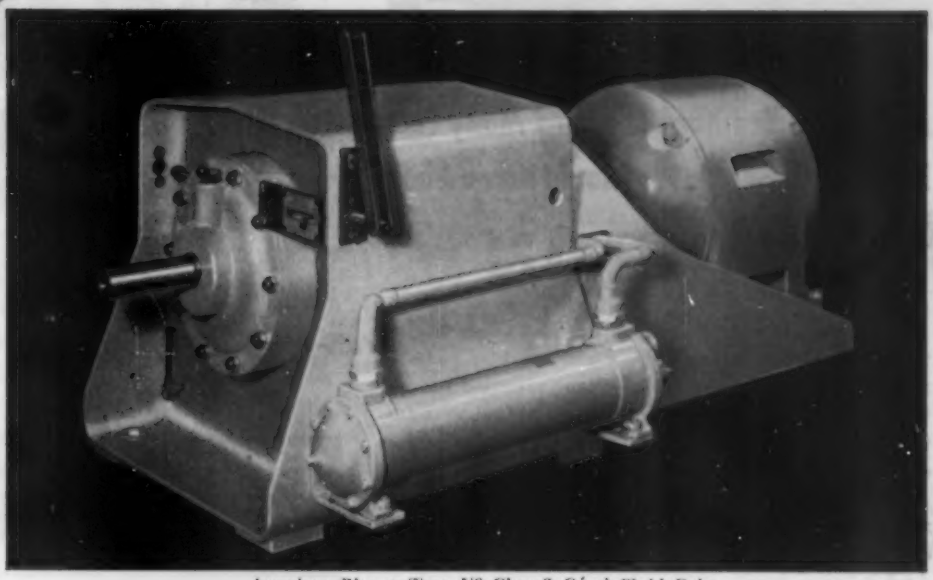
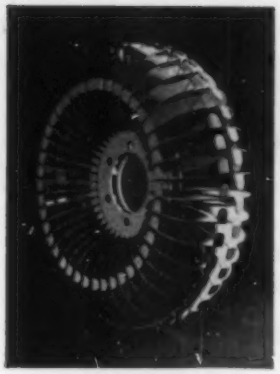
Gýrol FLUID DRIVE

TYPE VS CLASS 2



American Blower Type VS Class 2 Gýrol Fluid Drive

- **Can be reversed while in motion at any variable operating speed by merely reversing direction of rotation of motor**
- **Permits adjustable speed control over a wide range**
- **Built in several standard arrangements**



A phantom view of the driving and driven members, which provide smooth, reversible power transmission.

HERE IT IS! A brand-new fluid drive that will help you solve many tough industrial-drive problems. It's the American Blower Type VS Class 2 Gýrol Fluid Drive. A compact, self-contained, adjustable speed unit.

The result of years of development and research, this adjustable-speed fluid coupling is crammed with features. It has unlimited application possibilities, with its wide-range, stepless speed, reversible control. Even on constant-torque loads, a 4-to-1 speed range is obtainable!

It permits driving motors to reach full-load speed before engaging the load. In many cases simple across-the-line starting may be used. Adjustable speed may be obtained by either automatic or manual adjustment of the speed-control lever.

The new Type VS Class 2 Gýrol Fluid Drive is available in six sizes . . . 7½ through 800 h.p., at normal motor speeds up to 1800 r.p.m. Built in five standard arrangements, it can be used on a wide variety of industrial applications.

For complete information about the Class 2 Gýrol Fluid Drive, give your nearest American Blower Branch Office a call, or write us for Bulletin 9419.

For smaller applications the Type TM Constant Speed Gýrol Fluid Drive is available in ratings from 1 to 20 h.p.

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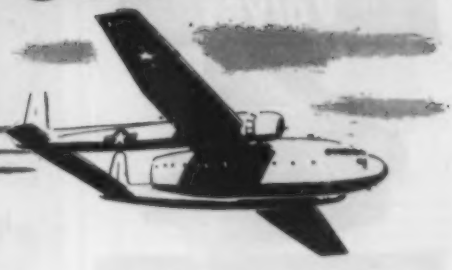
BIG NEWS!

ON PAGE 317

the FIRE TRUCK *that flies*

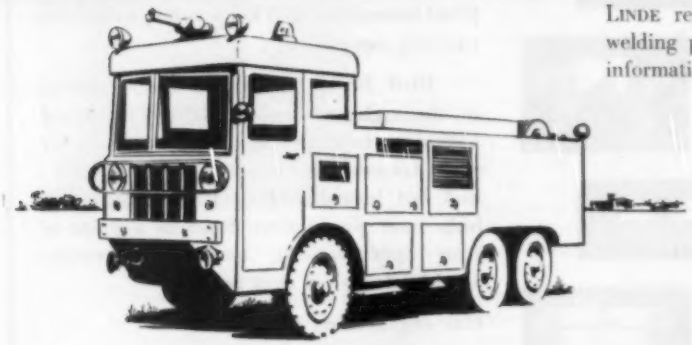


From rumbling horse drawn wagons, to the massive pump-trucks of today—weight has been the common characteristic of mobile fire-fighting equipment.

However, with the expanding science of fire-fighting, there came new demands of equipment. The United States Air Force had need for fire trucks fully equipped, yet light enough to be carried by air to landing strips the world over. Such trucks are now in production—fabricated by HELIARC and sigma welding.

The fire truck's rigid lightweight all-aluminum body, which varies in thickness from 14 ga. to ⅜ in., is completely welded by HELIARC and sigma welding at speeds up to 25 in. per minute. Because welding speed is high, and inert gas welding eliminates expensive post-weld cleaning, this manufacturer turns out three units a day—employing only 40 men.

Research and years of experience have helped LINDE to develop a top notch team of fabricating processes—HELIARC, sigma and UNIONMELT welding. For small shops or huge production lines, from carbon steel to complex alloys and non-ferrous metals—there is a LINDE electric welding process to do the job efficiently and economically. Your local LINDE representative will help you determine the best welding process for your job. Call him today for more information.



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A Division of Union Carbide and Carbon Corporation
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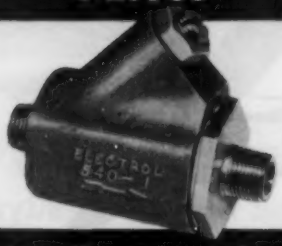
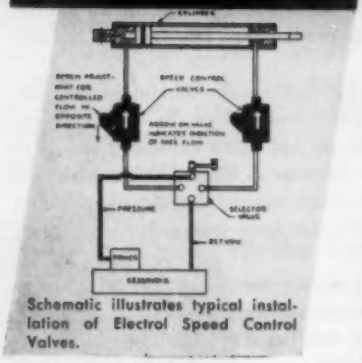
Electrol Speed Control Valves



Handle Air...Oil or Water with Operating Pressures up to 1,500 P.S.I.



Schematic illustrates typical installation of Electrol Speed Control Valves.

Electrol Speed Control Valves are designed to handle air . . . oil or water with operating pressures up to 1,500 P.S.I. They allow free flow in one direction and—by use of a metering device and check valve— accurately control reverse flow from 0 to valve maximum, even after thousands of cycles. They are available with ⅛", ¼", ⅜", ½" and ¾" N.P.T. ports. Your inquiries will receive prompt attention.

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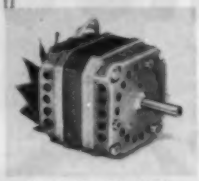
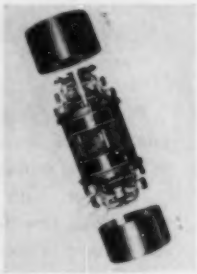


Model No. MS–3600
Shaded Pole Motor



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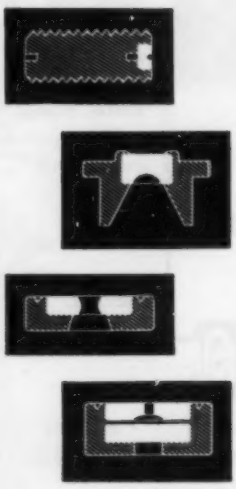

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Spectrum Recorder Model BL-2311

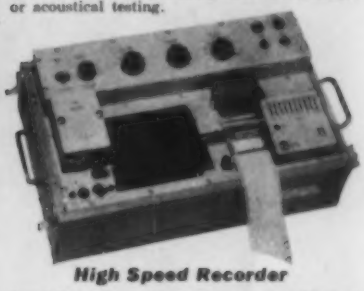
Since these new instruments present essential data so easily, they greatly simplify the analysis and control of sound, vibration, and noise.

For example, the Spectrum Recorder automatically "scans" any sounds from 35 to 18,000 cycles per second in third-octave steps. Chart records, produced immediately, indicate both frequency spectrum and signal amplitude. The instrument saves hours of engineering time in analysis of sounds and vibrations, and in studies of strains, pressure variations, complex electrical voltages, and magnetic tape recordings.

Developed for laboratory use by Bruel & Kjaer, these instruments are finding ever-broader use in industry. For information on acoustical and electro-acoustical measurements that can be made easily with these instruments, write Brush Electronics Company, Dept. A-4, 3405 Perkins Avenue, Cleveland 14, Ohio. Send coupon today.

Speeds Frequency Analysis

The Audio Frequency Spectrometer measures amplitudes of the frequency components in complex a.c. voltages from 35 to 18,000 cps. Saves hours of engineering time in electrical or acoustical testing.



High Speed Recorder

Level Recorder makes high speed recordings of signal level variations. Simplifies obtaining frequency response curves; useful in recording reverberation decay curves, noise levels, electrical voltage levels.

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Beat Frequency Oscillator is a complete and flexible signal source. When coupled with the Level Recorder, Oscillator automatically sweeps through the audio frequency range. Permits fast, accurate recording.

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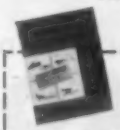

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We invite you to write for Catalog 98 today.

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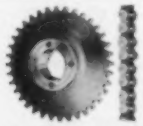
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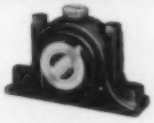
TAPER-LOCK SHEAVES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- Pressures
- Weights
- Liquid Levels
- Excursion
- Expansion
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- Generation of electrical functions
- Analog Computation

MONITORING AND CONTROL

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- Compensation of aberrated motions may be made by choice of potentiometer windings of the non-linear type

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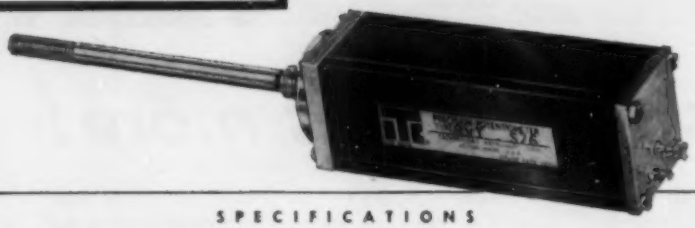
- RVT Potentiometers reliably replace the human watchman or operator in dangerous or injurious environments, and safely provide remote indication, alarm operation, or control surveillance.

The exacting standard of performance that TIC has made famous in precision rotary potentiometers has been applied to the field of straight-line or rectilineal shaft motion potentiometers. A guided centerless ground stainless steel shaft is free to move longitudinally down the axis of a machined aluminum housing. The shaft carries up to three separate dual contacts of precious metal which slide upon as many precision wound resistor strips, giving resistance variation proportional to the shaft motion. Units having multiple strips and contacts preserve the electrical individuality of each so that many wiring combinations are possible for control of sensitivity, resolution or electric current function features.



SPECIFICATIONS

Standard Stroke Lengths:	2½"	5"	8"	12"*
Dissipation @ 25°C.:	2.5w	5w	6w	8w

Independent Linearity:** ± 1% of total res. for 2½" and over.
**Under 2½": ± 2.5% to ± 5% of total res.

Resistance Range: 100 ohms/in. to 25,000 ohms/in.

Resistance Tolerance: ± 5%

Overtravel: Coin silver end tabs — no change in resistance in overtravel regions.

Ambient Temp. Range: −55° to + 80°C.

Temperature Coefficient of Resistance Wire: .00002/°C.

Life: 1,000,000 traverses over resistance element @ speed of 1"/sec. or less.

Resistance Winding: Up to three independent linear or non-linear windings may be included in one unit.

Housing: Sturdy machined aluminum with corrosion resistant anodized finish. Threaded bushing provides simple mounting. Terminals to all elements accessible at rear of housing. Housing has 1¼"x1¼" cross sectional area, length determined by stroke.

*Non standard stroke lengths ½" to 12" available.

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In other sections of the File you will find additional catalogs containing useful information on product forms, characteristics, performance and use.

Sweet's Catalog Service

Division of
F. W. Dodge Corporation
119 West 40th Street,
New York 18, N. Y.

To the Employee Relations Director of every American company

LET'S FACE IT . . . the threat of war and the atom bomb has become a real part of our life—and will be with us for years. Fires, tornadoes and other disasters, too, may strike without warning.

The very lives of your employees are at stake. Yours is a grave responsibility. Consider what may happen.

When the emergency comes, everybody's going to need help at the same time. It may be hours before outside aid reaches you. The best chance of survival for your workers—and the fastest way to get back into production—is to know what to do and be ready to do it. To be unprepared is to gamble with human lives. Disaster may happen TOMORROW. Insist that these simple precautions are taken TODAY:

☐ **Call your local** Civil Defense Director. He'll help you set up a plan for your offices and plant—a plan that's safer, because it's entirely integrated with community Civil Defense action.

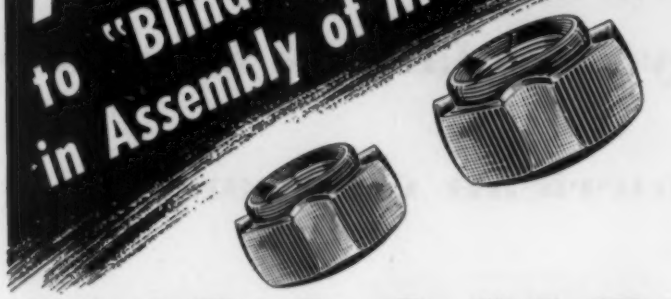
☐ **Check contents** and locations of first-aid kits. Be sure they're adequate and up to date. Here again, your CD Director can help—with advice on supplies needed for injuries due to blast, radiation, etc.

☐ **Encourage personnel** to attend Red Cross First Aid Training Courses.

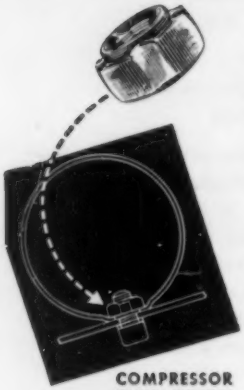
☐ **Encourage your staff** and your community to have their homes prepared. Run ads in your plant paper, in local newspapers, over TV and radio, on bulletin boards. Your CD Director can show you ads that you can sponsor locally. Set the standard of preparedness in your plant city. There's no better way of building prestige and good employee relations—and no greater way of helping America.

Act now . . . check off these four simple points . . . before it's too late.

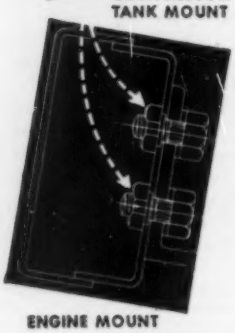
The ANSWER to "Blind Spot" Problems in Assembly of Metal Parts



MIDLAND WELDING NUTS



COMPRESSOR TANK MOUNT



ENGINE MOUNT

● Welded to inside spots, where it is difficult or impossible for hands or tools to reach, MIDLAND WELDING NUTS hold fast while bolts are turned into them.

This method speeds up the assembly of metal stampings, and helps spread the use of manpower. Midland Welding Nuts enable one man to do the work formerly requiring two, while one worker held old style nuts from turning.

Investigate the need for Midland Welding Nuts in your plant. Write or phone for complete information.

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6660 Mt. Elliott Ave • Detroit 11, Mich.
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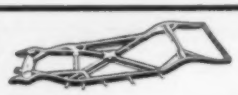

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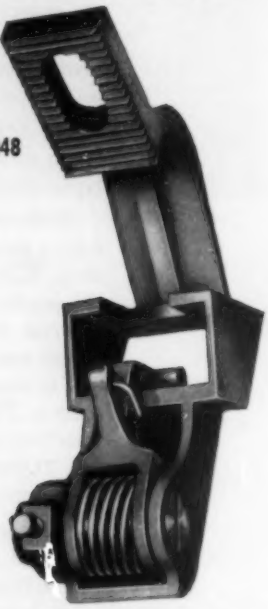

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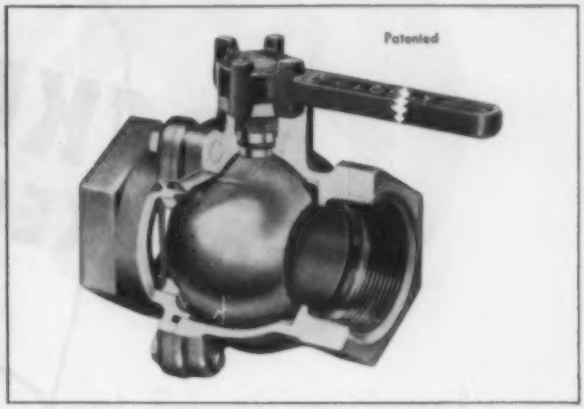

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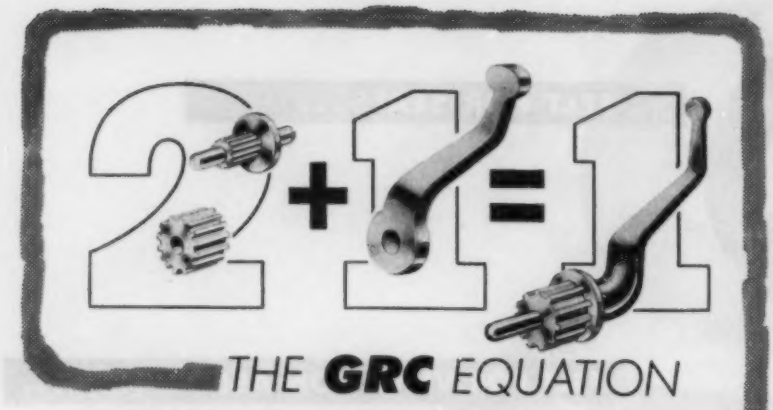

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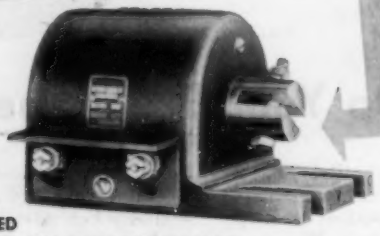

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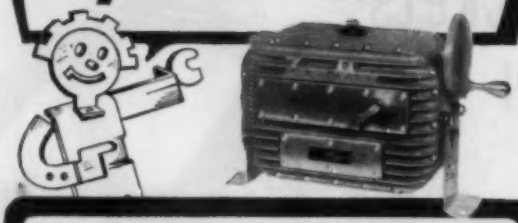

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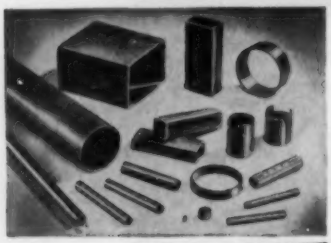

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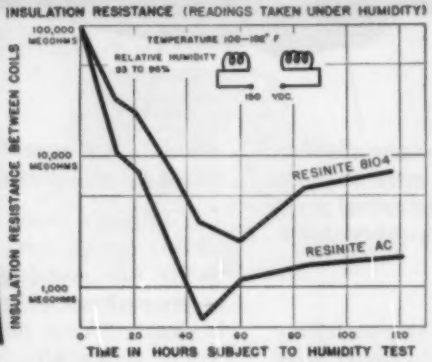

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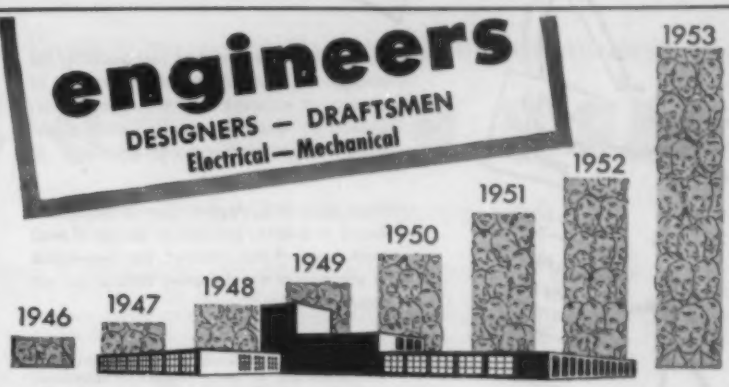

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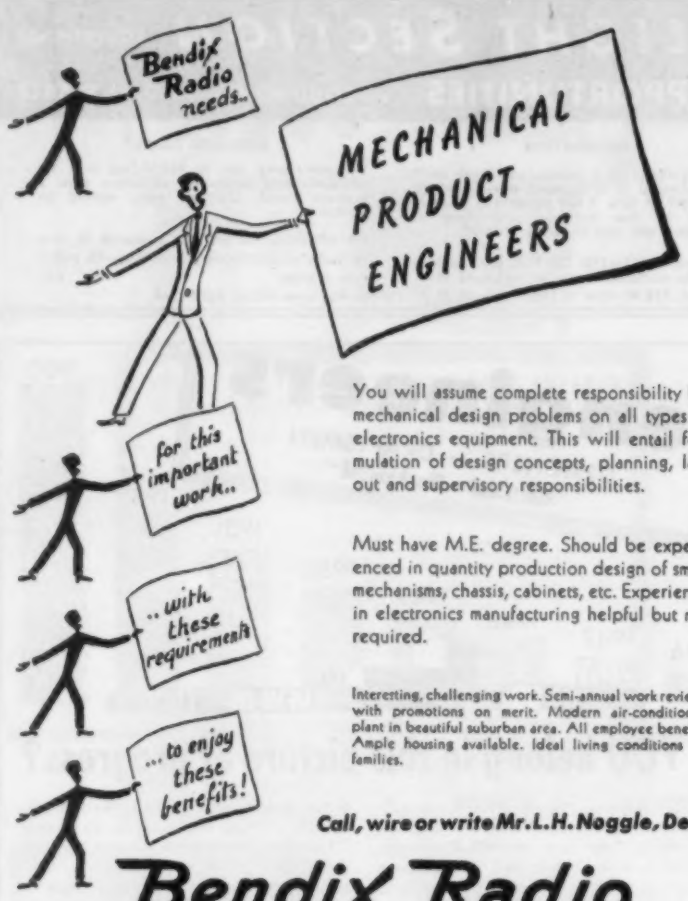

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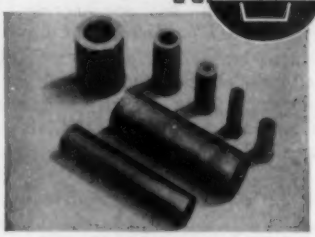

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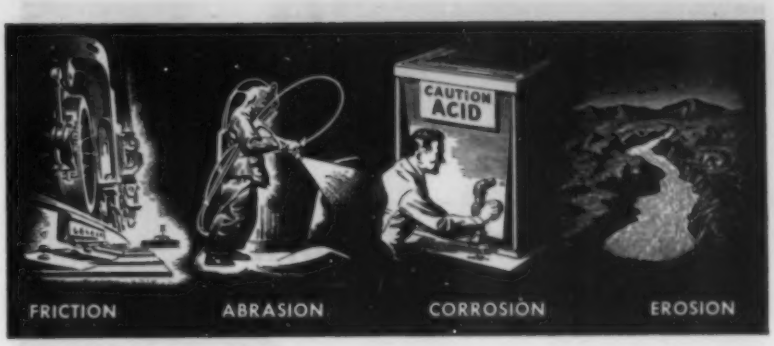

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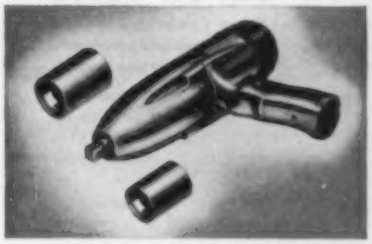

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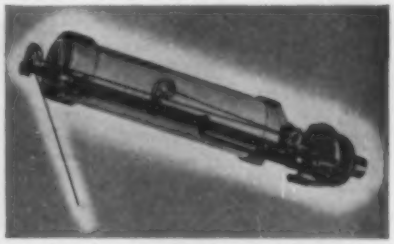
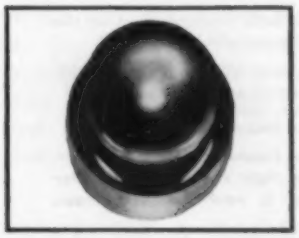


In textile mills, threads traveling at high speeds quickly cut through steel or porcelain guides. Carbide guide ring inserts, used to resist such wear, lasted 50 to 100 times longer. They also greatly reduced thread snagging and snapping, spoilage and downtime.



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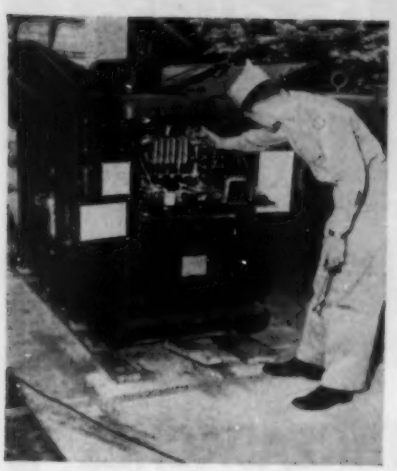

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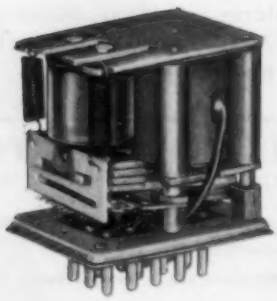

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Subject: APEX Quick-Change Universal Joint Assemblies

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APEX universal joint assemblies

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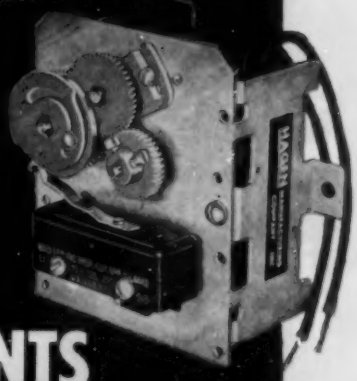

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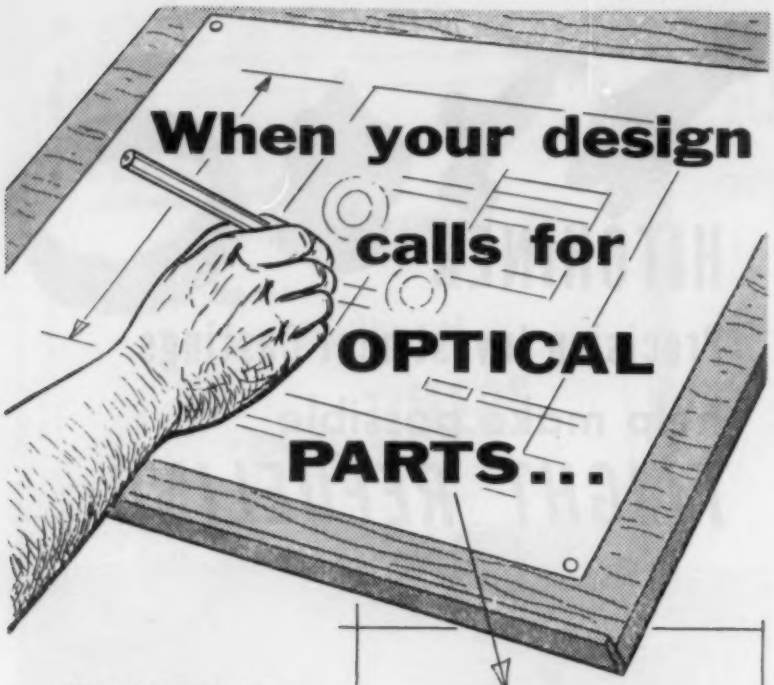

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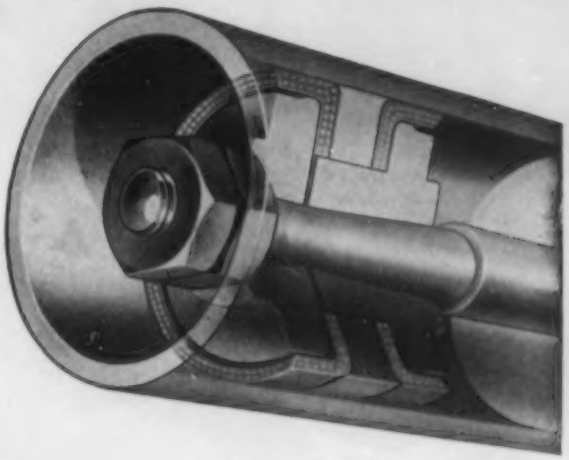
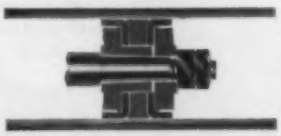
more efficient...job after job!

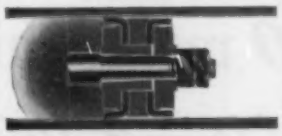


Phantom cutaway showing a typical Pumcup piston assembly.

DIAGRAM OF DARCOVA PUMCUP ACTION (greatly exaggerated)



NORMAL: BOTH PUMCUPS RELAXED



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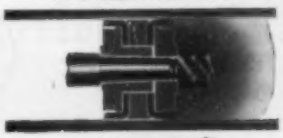

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PUMCUPS

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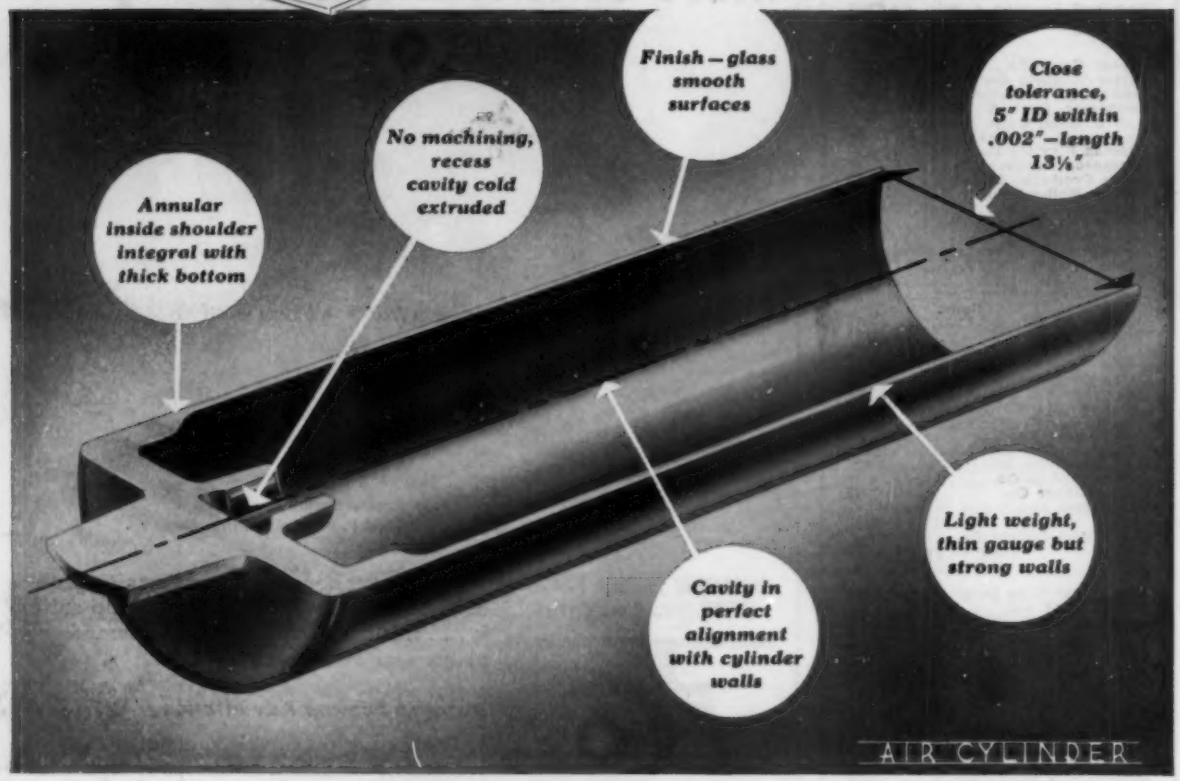
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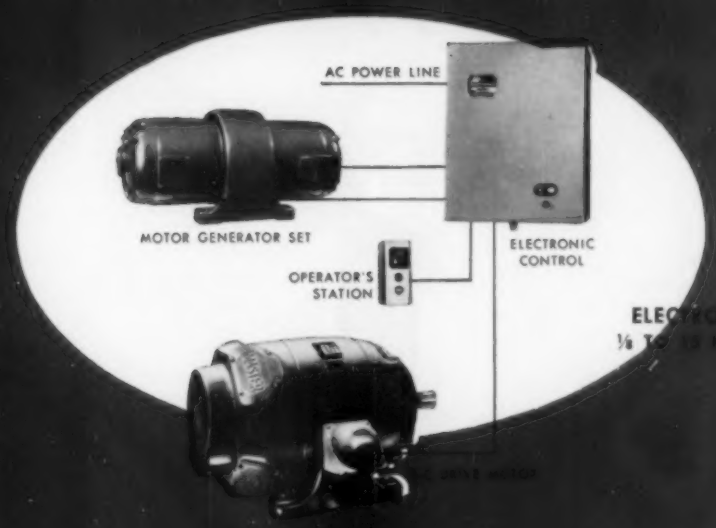
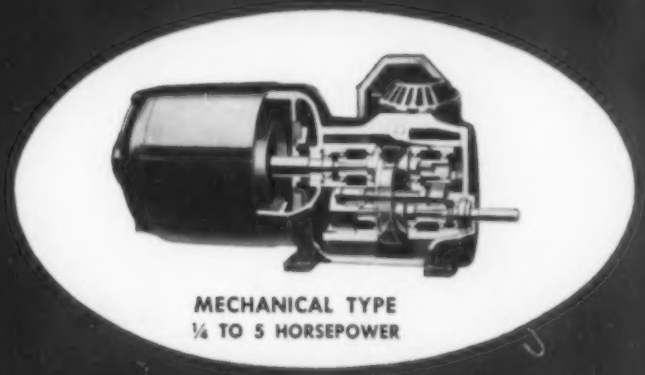


ELECTRONIC TYPE
⅛ TO 15 HORSEPOWER



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¼ TO 5 HORSEPOWER

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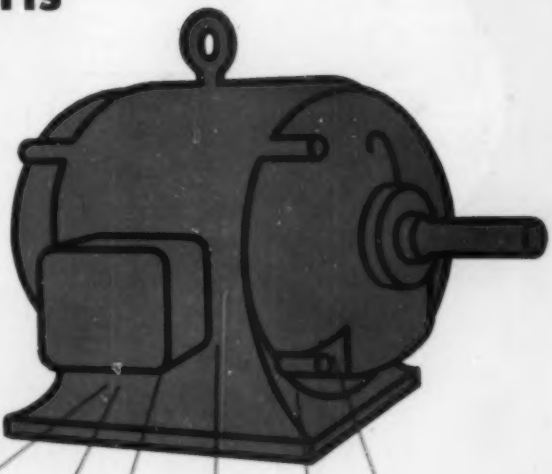
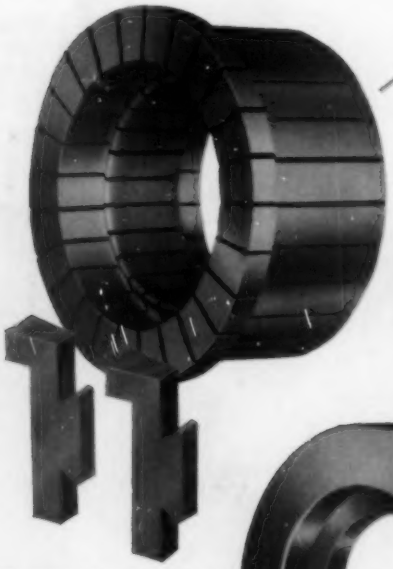
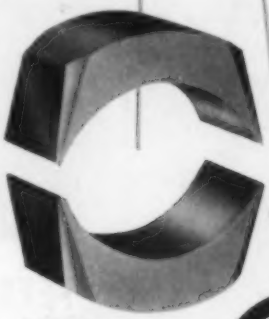




GRAMIX commutator segments

GRAMIX bearings



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